Laboratori d'Arqueologia Quantitativa
UNIVERSITAT AUTONOMA DE BARCELONA

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Spatio-Temporal Analysis in Archaeology

What does it mean? “ANALYSIS”

Distinction and separation of parts of a whole in order to know their principles, elements, etc.

Qualitative and quantitative examination of certain components using specialized methods

Study of limitations, characteristics and possible solutions to a problem

What does it mean?
SPATIAL “ANALYSIS”

Can we distinguish and separate parts of “space” to get to know its principles, elements, etc..?

Can we examine qualitatively and / or quantitatively the “spatial components” using specialized methods?

Is "space" a problem whose possible solutions can be formally addressed?

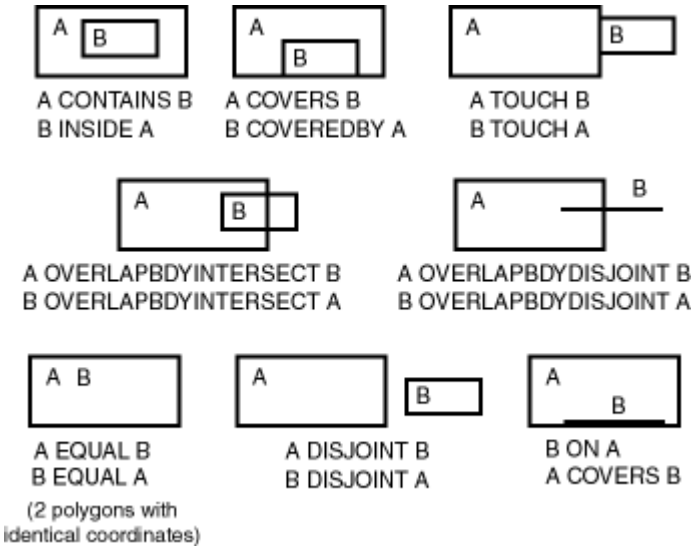
What is this thing we usually call “space”?

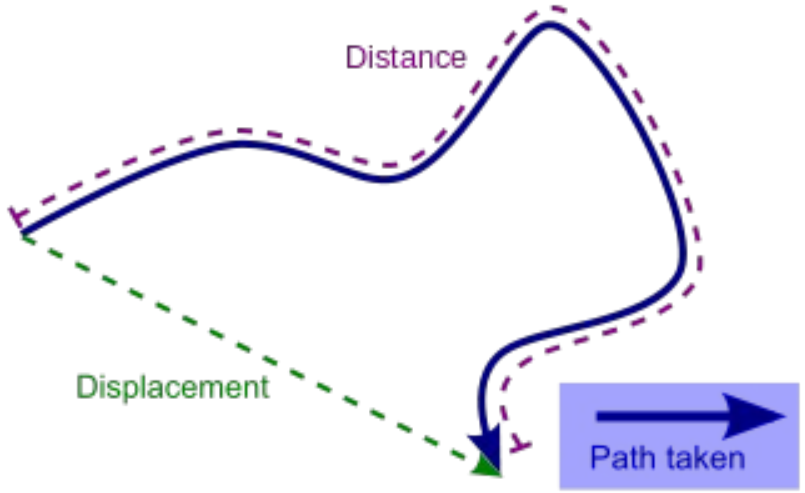
e is a relational structure called“space” because we move around some things a
gs can move or be moved around us

we do not move, or things around us remain fixed, we hardly had an idea of “spa

“Space” does not exist as a physical thing, but physical relationships I have with things around me

The idea of DISTANCE

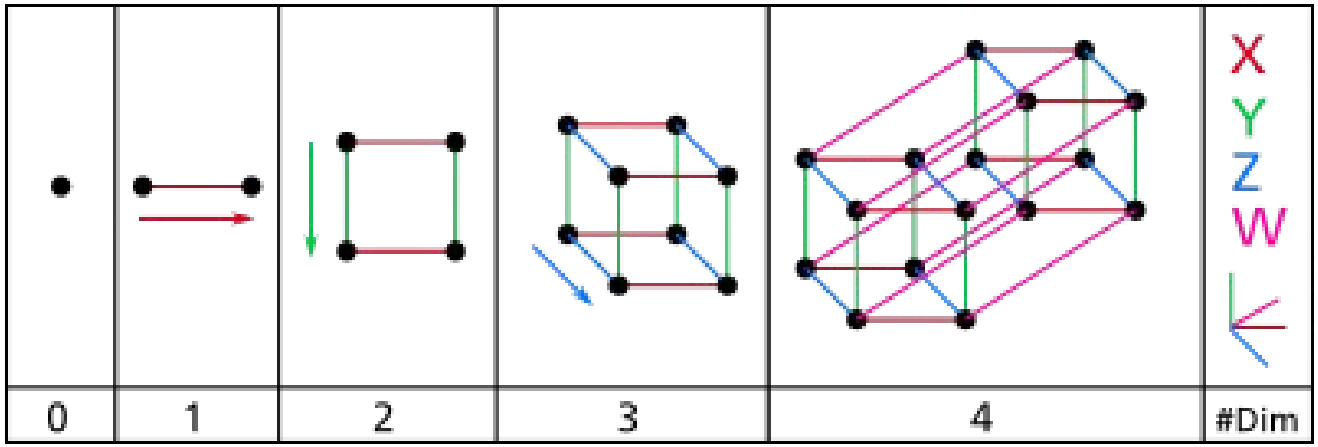




in mathematics, the distance between two points in Euclidean space is equivalent to the
segment length of the straight line joining expressed numerically.
In more complex spaces, as defined in the non-Euclidean geometry, the "shortest path" between two points is a straight segment.

“place” (location) is NO INTRINSIC PROPERTY TO OBJECT, BUT FEATURES OF THE OBSERVATIONAL ACT

In general , in a physical system or otherwise, the term position is used to refer to distinct physical condition or situation that the system exhibits . This is common to speak of the position of the system in a diagram that illustrates the system state variables

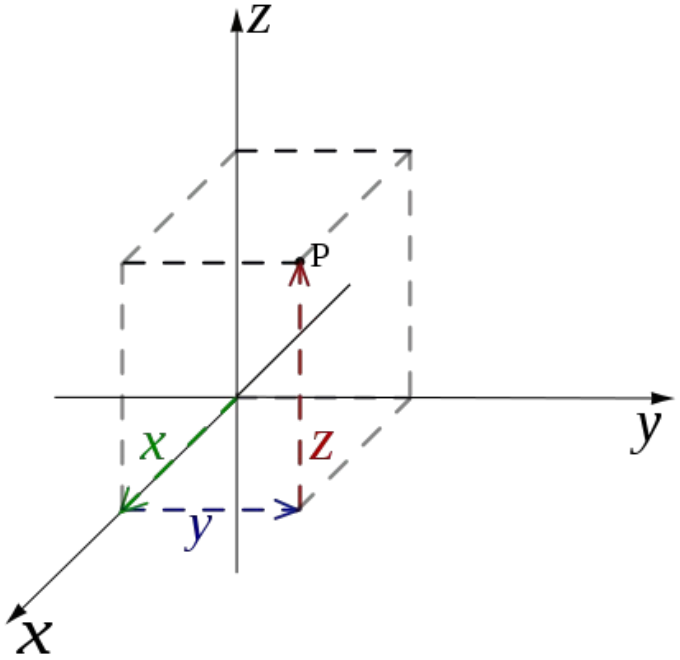


“place” (location) is NO INTRINSIC PROPERTY TO OBJECT, BUT FEATURES OF THE OBSERVATIONAL ACT

In physics , the position of a particle indicates its location in space or space - time. It is represented by coordinate systems.

In classical mechanics , the position of a particle in space is represented as a vector quantity with respect to a reference coordinate system.

In general relativity, the position is not representable by a Euclidean vector, as in the space-time is curved in such a theory , so the position must necessarily be represented by a set of arbitrary curvilinear coordinates , which generally can not be interpreted as the



In quantum mechanics, the representation of the position of a particle is even more complex due to non local effects related to the problem of measurement of quantum

What about “Time”....?

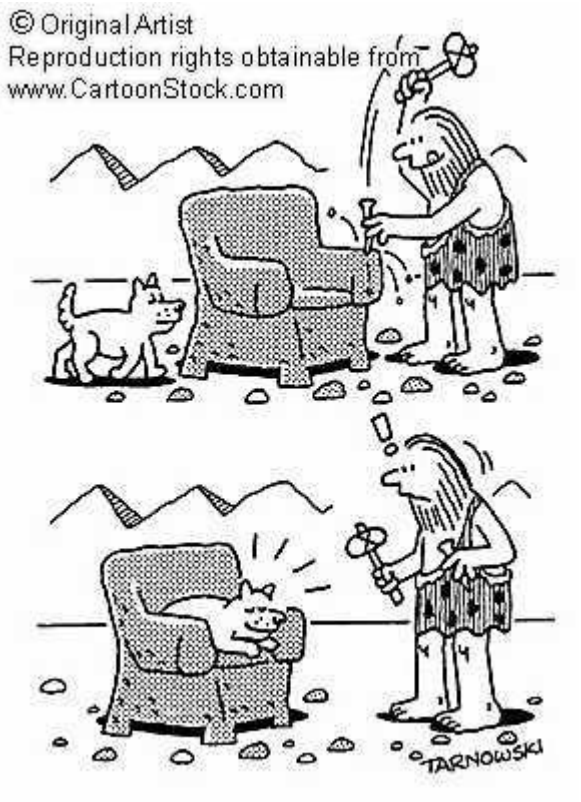
...has it anything to do with “space”

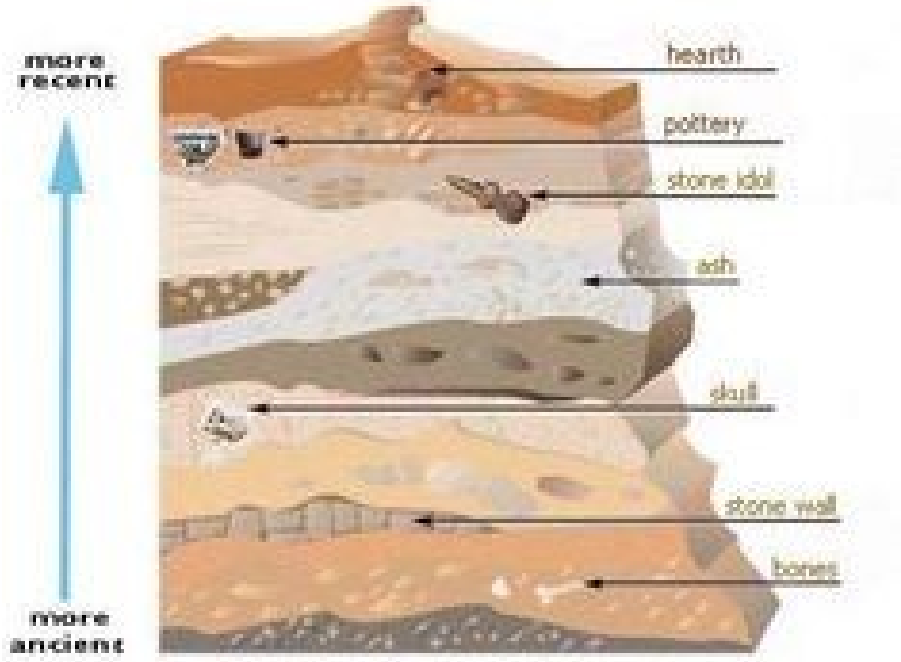
“Moment” (temporal position) is NO INTRINSIC PROPERTY TO OBJECT, BUT
FEATURES OF THE OBSERVATIONAL ACT

A temporal event is an expression of the fact that some kind of social activity has taken place somewhere, and that, therefore, there is some *f* characteristic.

we also assume that this location is in a state *s* or the characteristics that define that state have changed or remain stationary (no change).

TIME IS NO MORE THAN THE EVIDENCE OF CHANGE



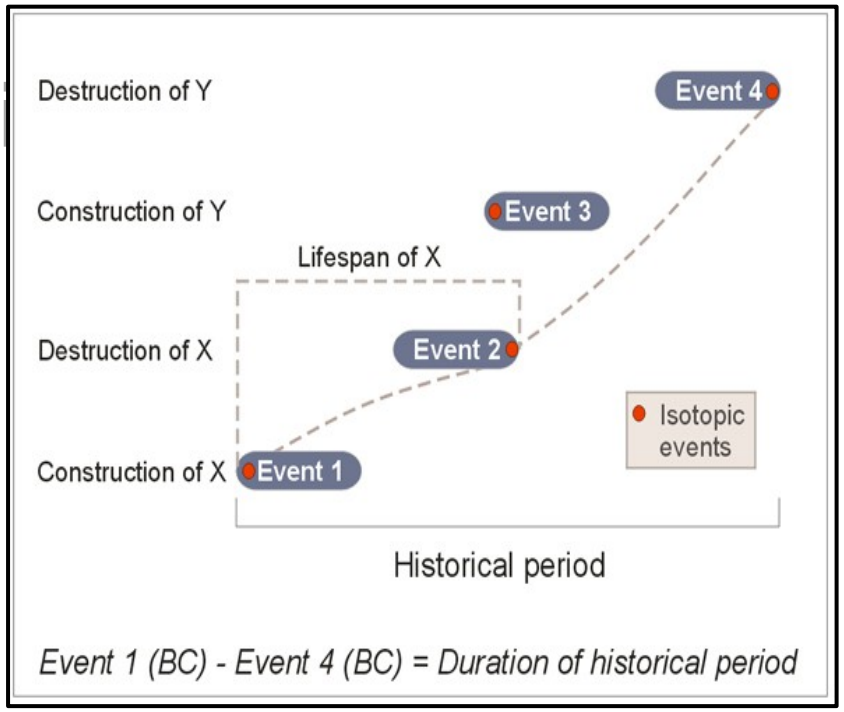


TIME IS NO MORE THAN THE EVIDENCE OF CHANGE

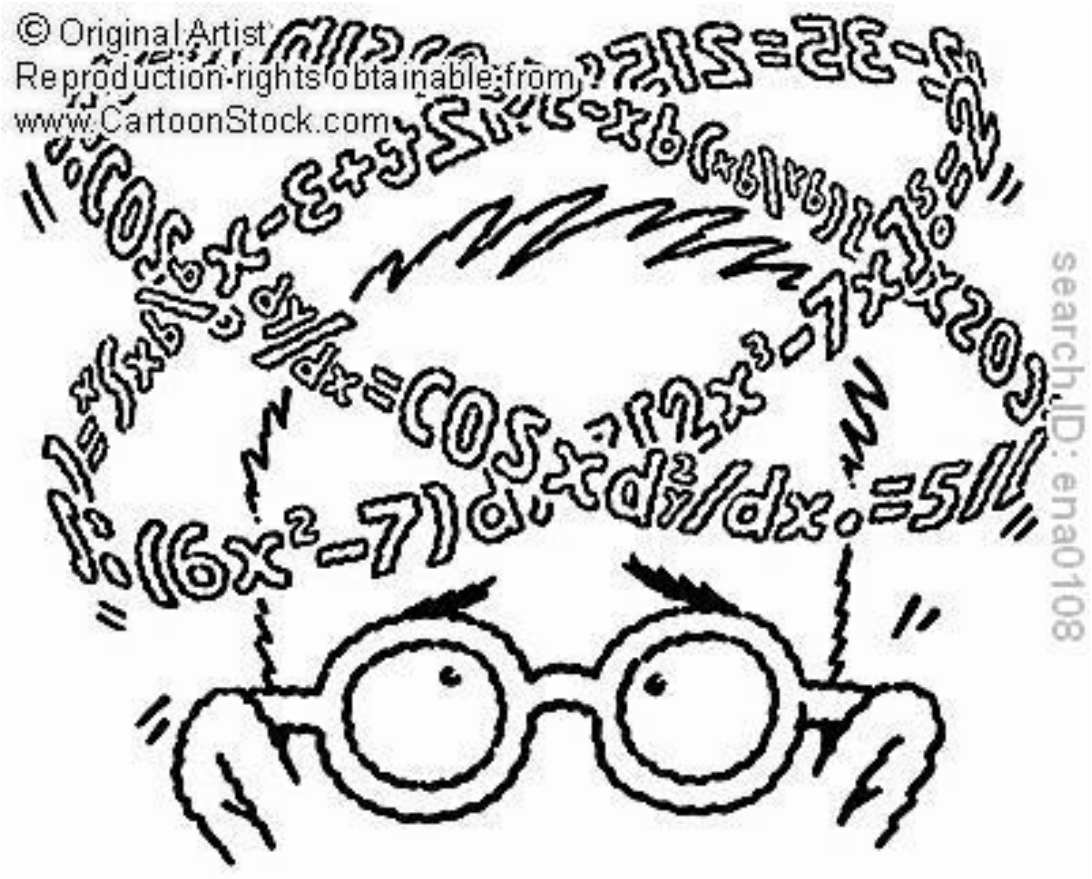
dimensionality of T

Sequence

Duration



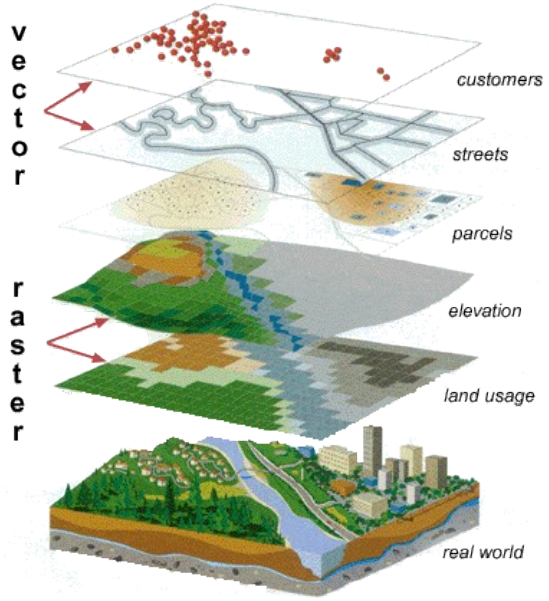
Consequently, if “space” and “time” exists only in our brain…..



What does it mean “spatio-temporal analysis”

Let’s try to “analyze” space 1

Can we distinguish and separate parts of “space” to get to know its principles, elements, etc..?



The problem of spatial decomposition:

The definition of SPATIAL VARIABLES

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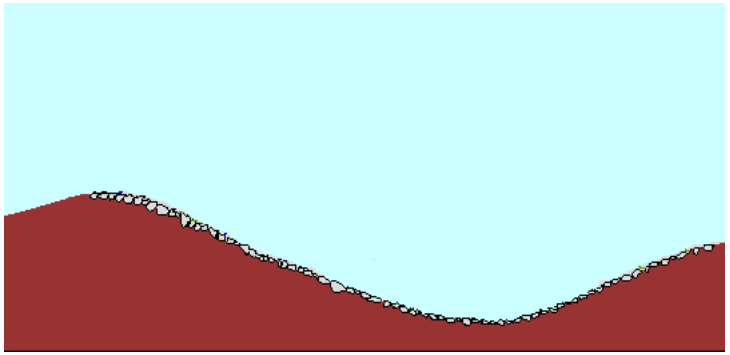

The problem of temporal decomposition:

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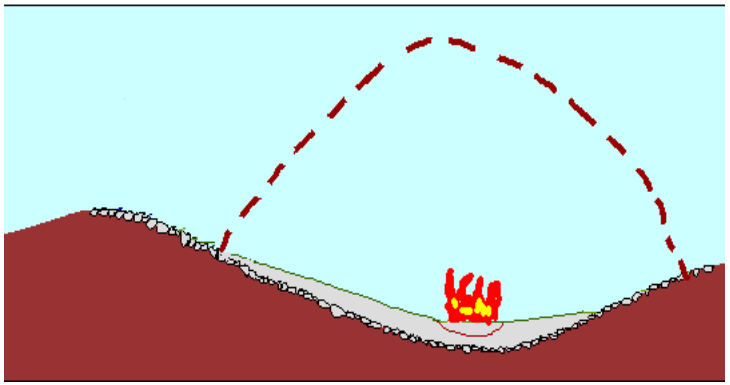

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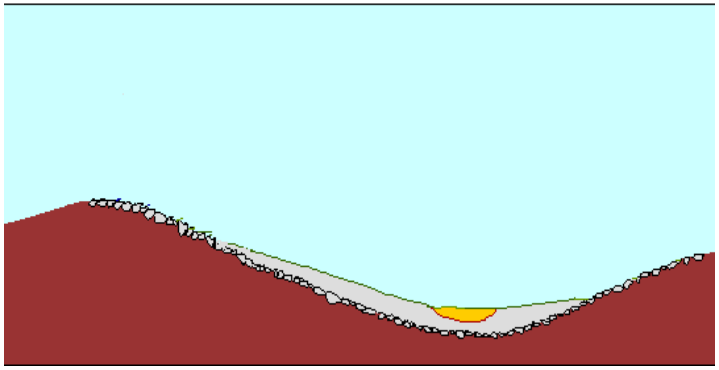

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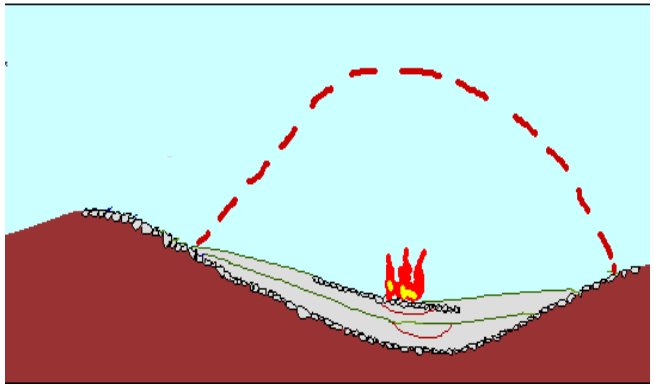

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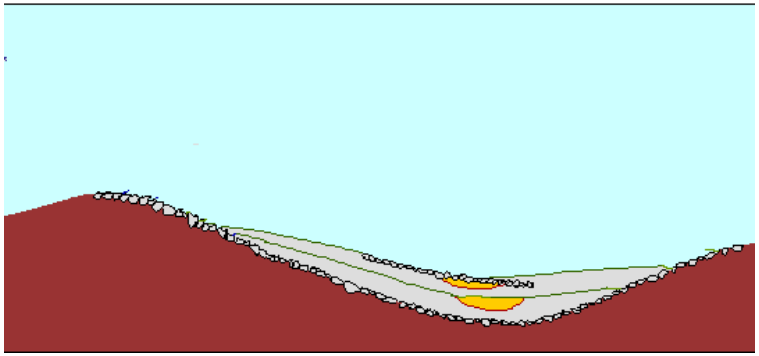

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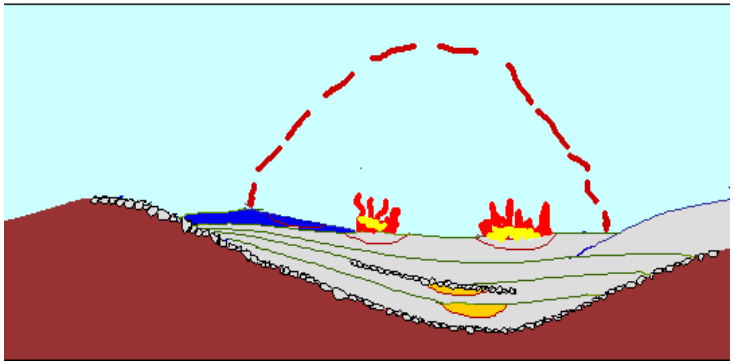

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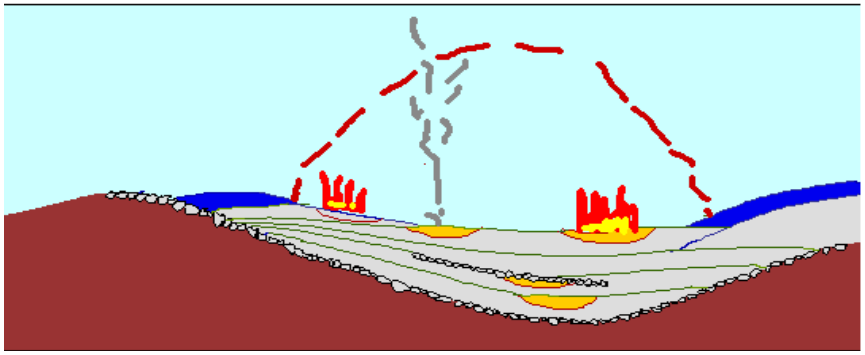

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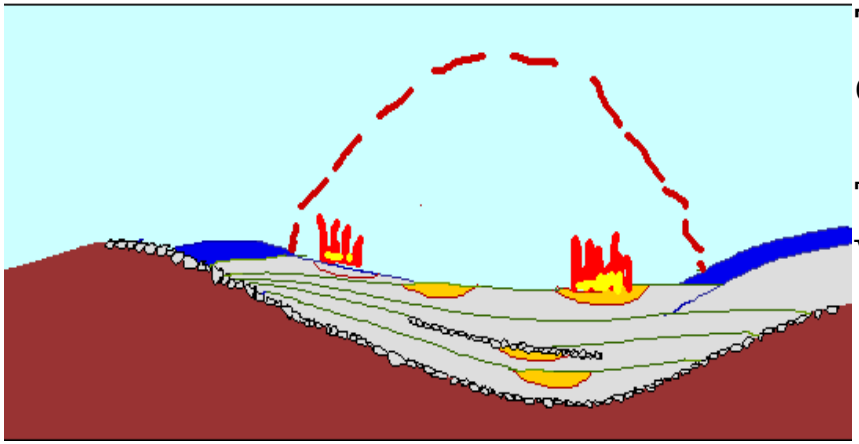

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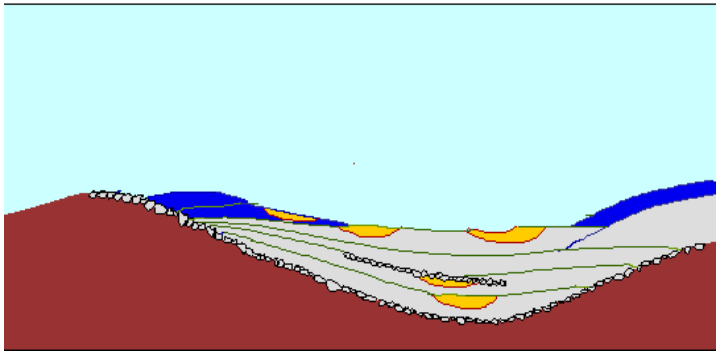

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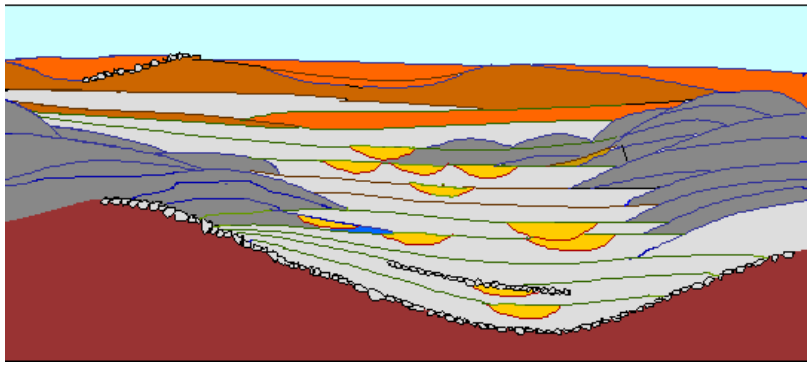


The problem of temporal decomposition:

The definition of temporal VARIABLES

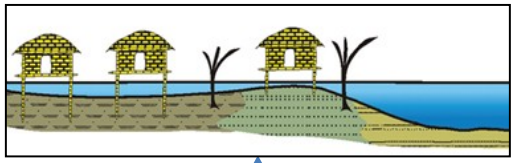
THE FORMATION AND DEFORMATION OF PREHISTORIC LAKESIDE SETTLEMENT

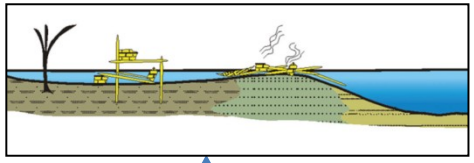
FROM LIFE

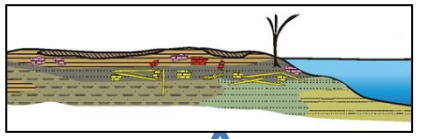
TO DEATH

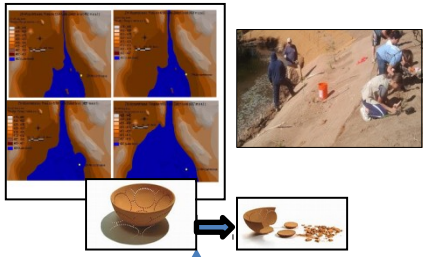
FROM PAST

TO PRESENT









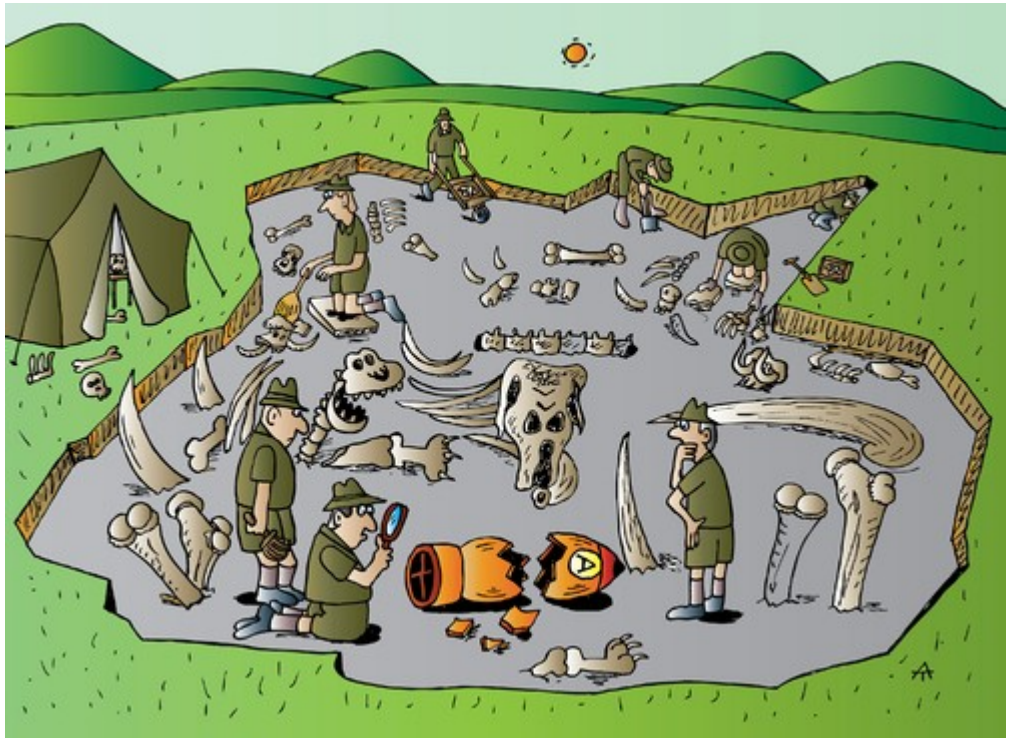
Depositional processes

Abandonment processes

Post depositional/taphonomic processes

ARCHEOLOGICAL RECORD

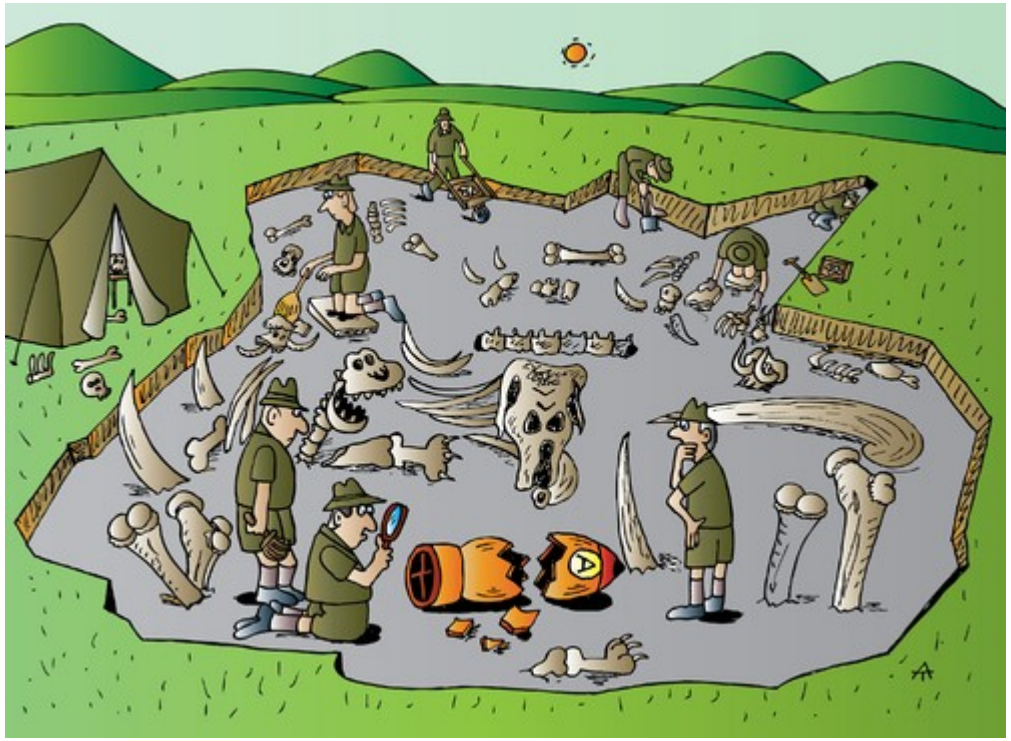
Let’s try to “analyze” space-time 1



Archaeological Space-Time:
Intersection of social agents, social activities and natural processes in space and through time.

Thousand of ways to decompose space into individualized variables:

Let’s try to “analyze” space-time 1



Archaeological Space-Time:

• ABUNDANCE OF WELL IDENTIFIED ARCHAEOLOGICAL CATEGORIES: COUNT DATA

•PRESENCE OF UNCOUNTABLE ELEMENTS: BUILT STRUCTURES

•ABSENCE: THE IMPORTANCE OF EMPTY SPAC E.

Let’s try to “analyze” space-time 1

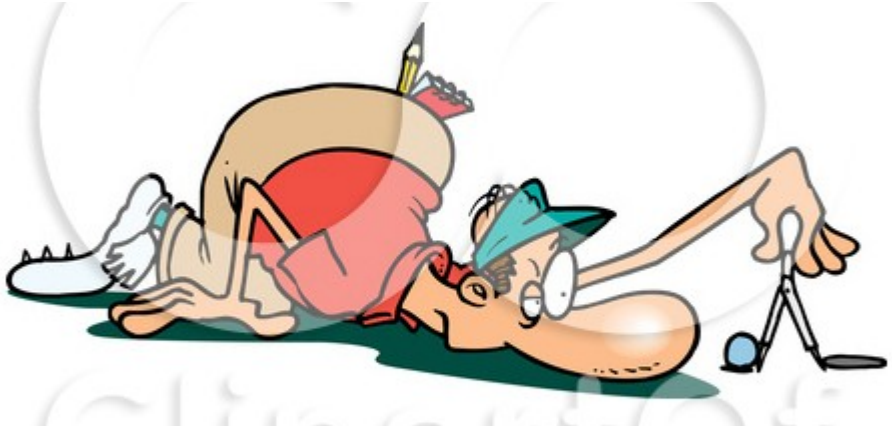
Can we distinguish and separate parts of “space” to get to know its principles, el

What is around me?
What has been changing since the very beginning?
Identification of observed discontinuities.

Theory of Observation: Physics, Chemistry,
Biology, Geology.

Let’s try to “analyze” space*time 2

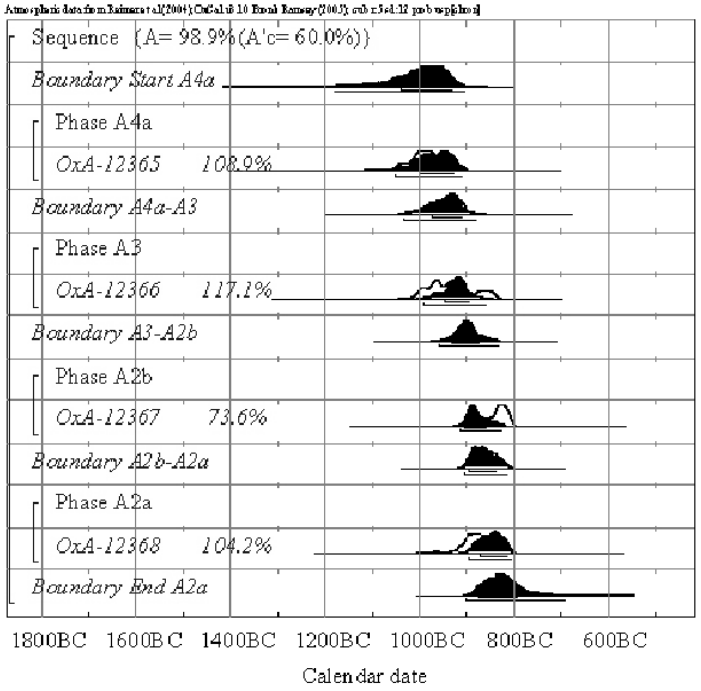
Can we examine qualitatively and / or quantitatively the “spatio-temporal components” using specialized methods?



"Measuring" space implies defining and quantifying the distance between objects that are “different”.

Let’s try to “analyze” space*time 2

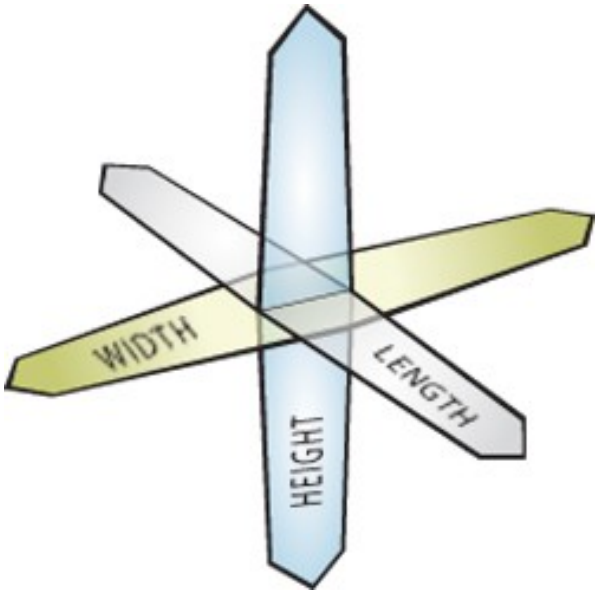
Can we examine qualitatively and / or quantitatively the “spatio-temporal components” using specialized methods?



"Measuring" time implies defining and quantifying the distance between two state changes

Let’s try to “analyze” space*time 2

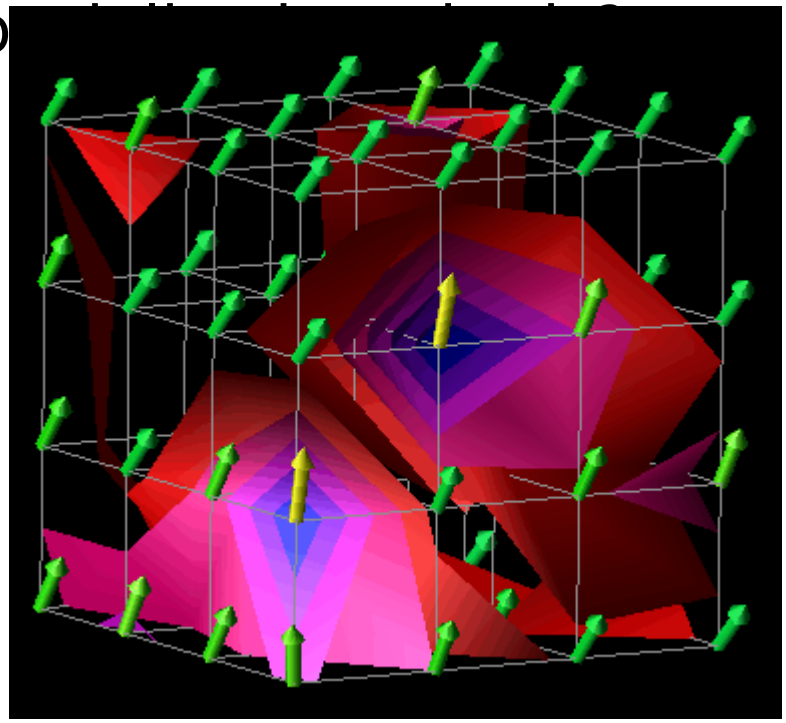
Can we examine qualitatively and / or quantitatively the “spatial components” using specialized methods?



The relevance of the 3 dimensions as the simplest representational schema. Below 3 D complete representation of space is impossible.

Let’s try to “analyze” space*time 2

Can we examine qualitatively and / or quantitatively the “spatial components” using sp



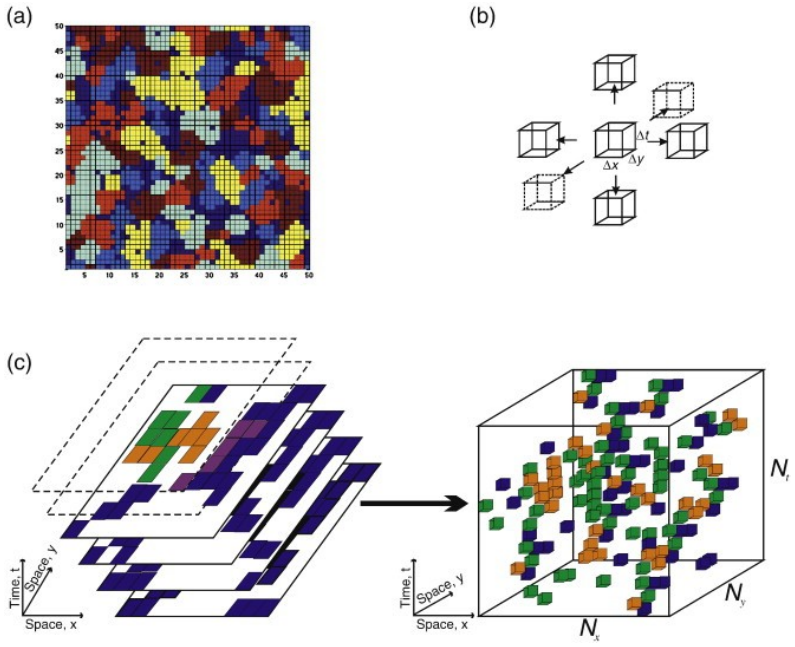
If we add Time (2 Dimensions), the minimum for representing archaeological space-Time is 5 Dimensions.

Representing Archaeological Space-Time

Each archaeological event will be represented as a five-dimensional vector

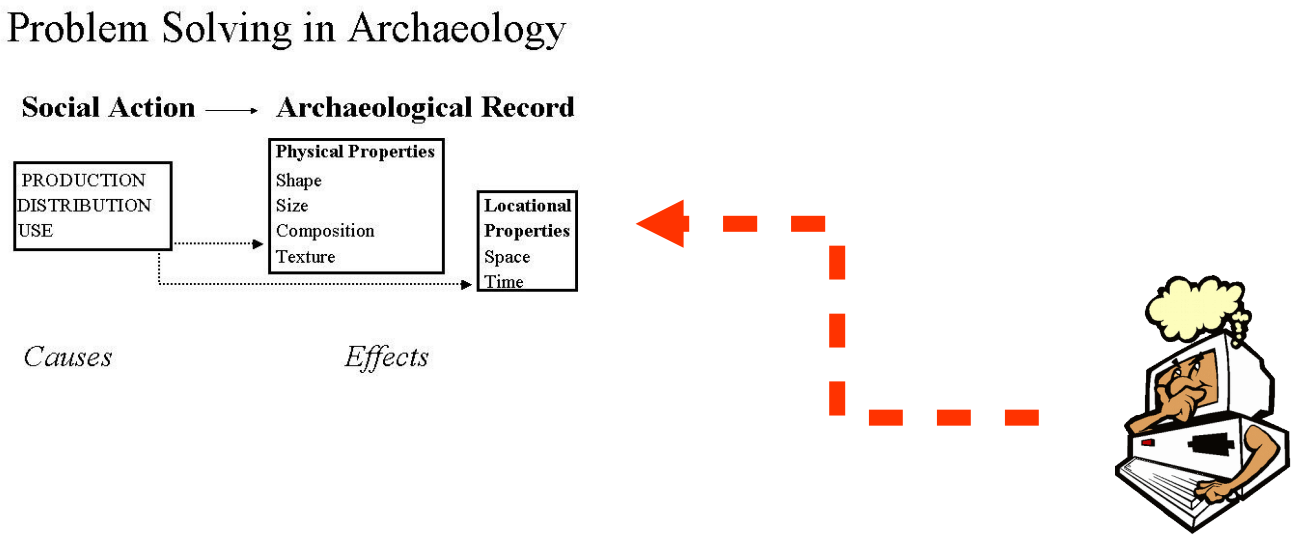
$$S_i\ (x,y,z,t_1,t_2)$$

Formally speaking, we represent five dimensions as succesive four-dimensional matrices (***x,y,z,*** S_i) for all temporal locations in the sequences.



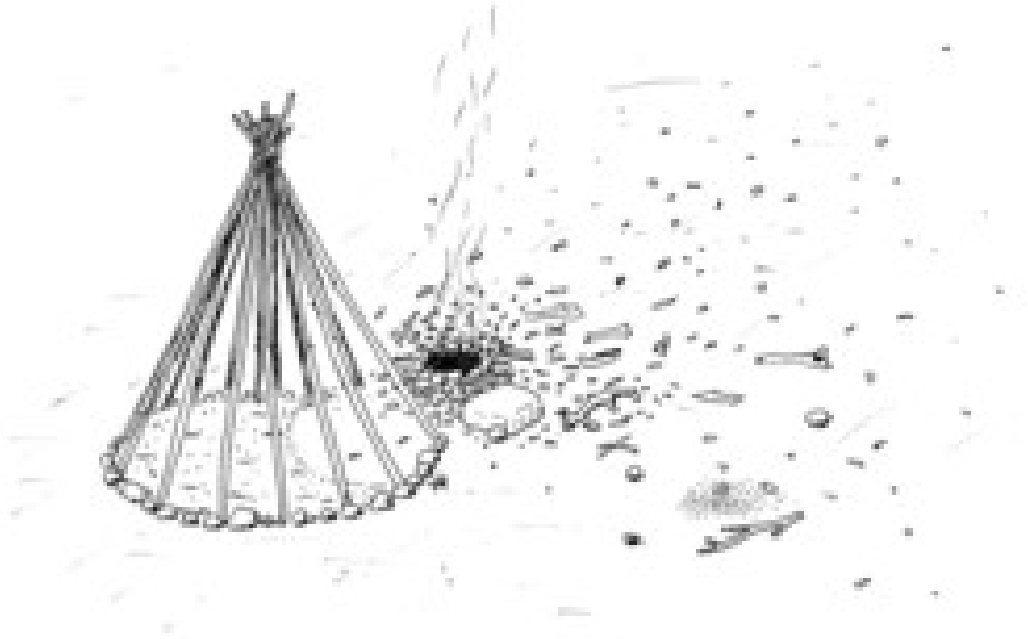
Let’s try to “analyze” space*time 3

Is "space" a problem whose possible solutions can be formally addressed?



The Nature of the Archaeological problem

Where activity X occurred?



Archaeological observables are not the activity, but something generated indirectly during the occurrence of the activity

The Nature of the Archaeological problem

Activity *X* took place there!

Intuitively: where count data are the more abundant

Why *X* occurred HERE and THEN?

Because “fire” happened there
And then

Why fire burned logs
there and then?


Because HE was also There and T
LDDS
MMX

The research process

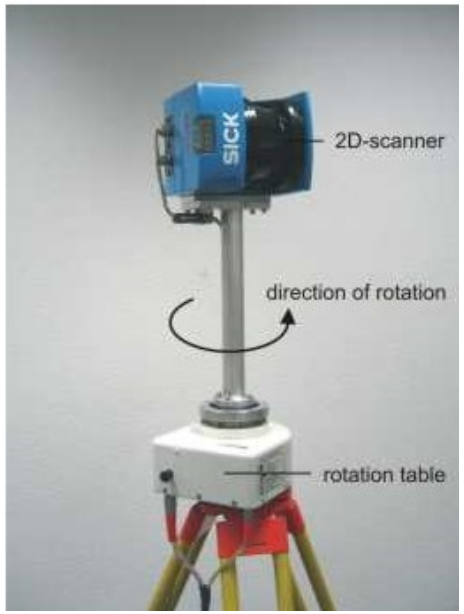
Explaining why social action took place there and not elsewhere

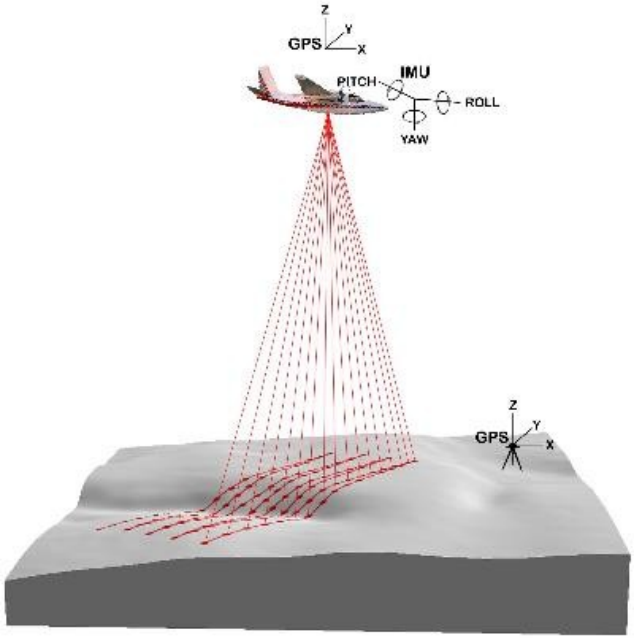
Simulating the results of social mechanisms

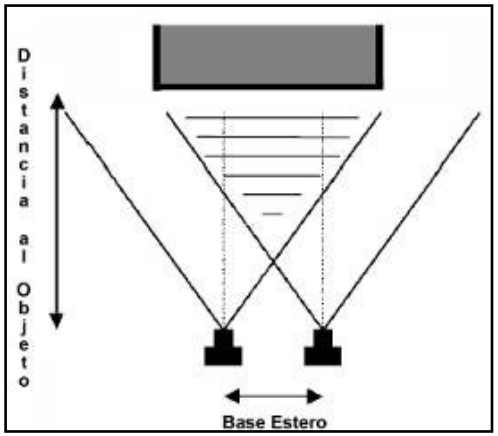
Measuring spatial-temporal variability

Observing the archaeologic al record

Measuring space

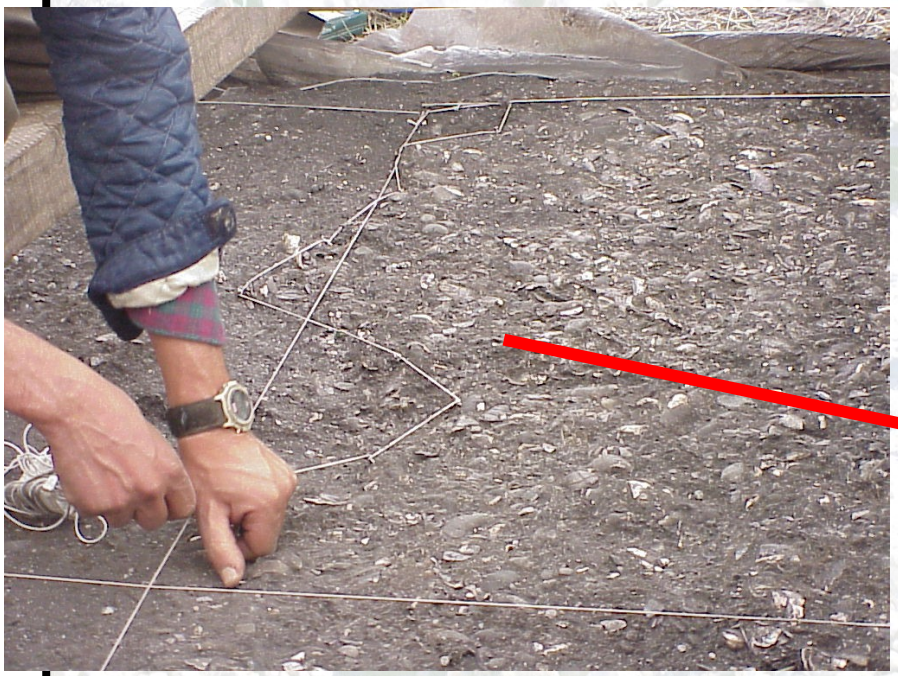






Archaeological Excavation

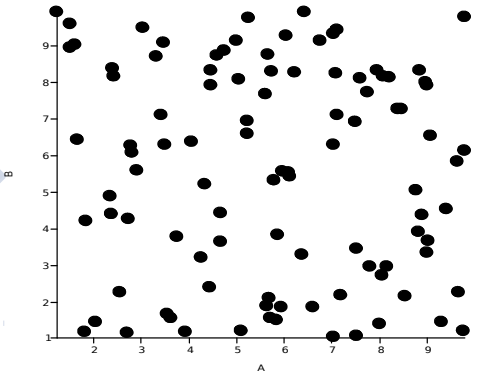
FREQUENCY
intensity



FORM
Interfacial boundary

Counting

•Enumeration of archeological evidences within the same variable or unit



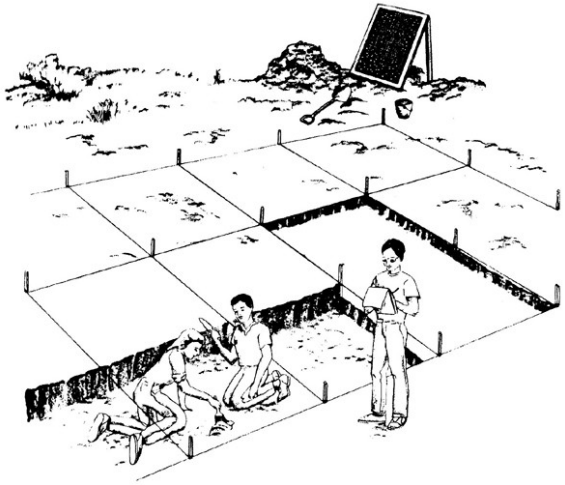
Frequency

•The intensity of action (its repetitions) took place in the past within a spatio-temporal unit, detectable through the material consequences in the archaeological record

?

Frequency of archaeological data:
an *accumulation* of some material items on the ground surface where the action took place or as the *intensity* of the action.

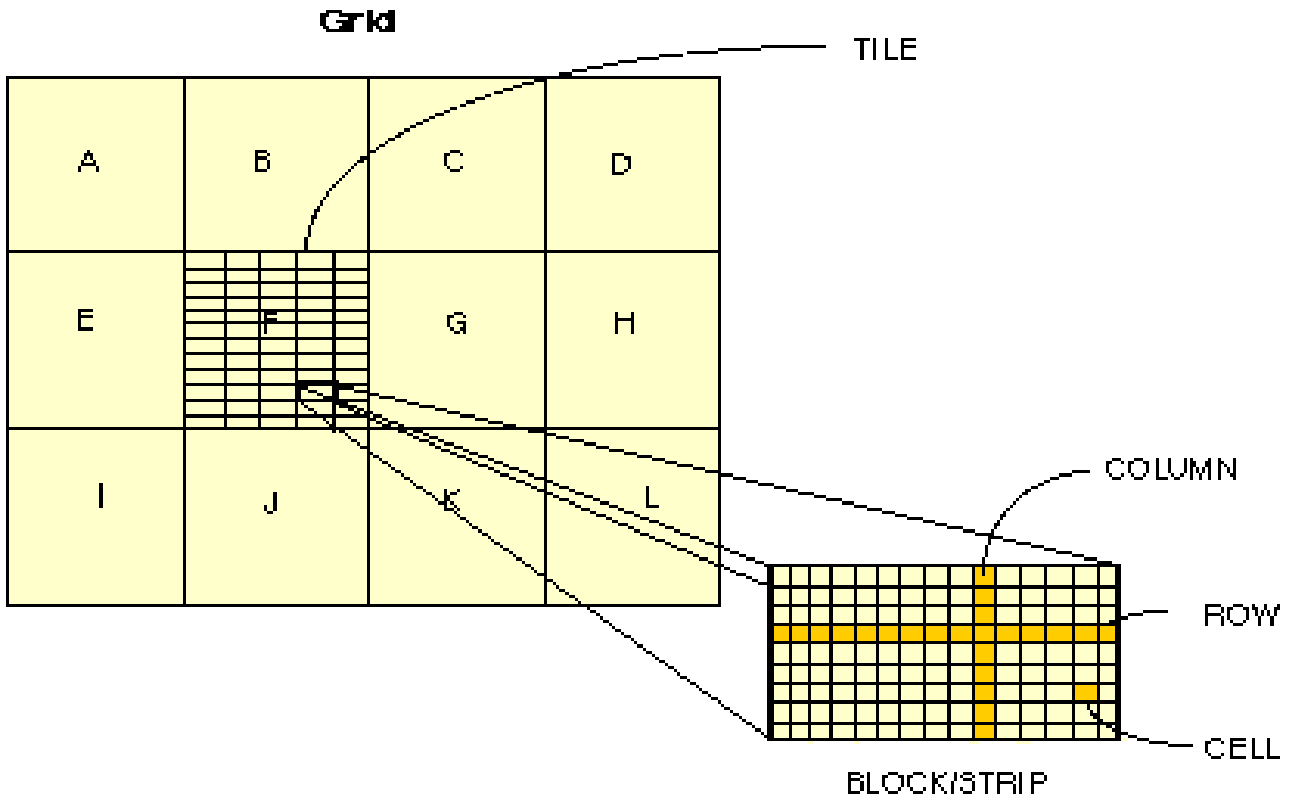
Additional Difficulties.
1. From Count data to Spatial Frequencies



Raw count observations are not reliable-
We need tpo convert count data into spatial frequer
By defining sampling units of equal spatial extensio
and temporal duration

It is easy to stress extension uniformity,

8	4	2	0	0	1	6	0	0	0	0
7	8	4	0	0	6	4	0	0	0	0
6	23	21	5	0	0	5	1	0	0	0
5	24	11	6	4	2	27	3	0	1	0
4	7	21	10	2	8	14	1	0	9	19
3	29	21	12	4	22	11	0	2	13	13
2	74	31	46	23	28	13	4	5	11	28
1	23	14	15	22	8	13	2	9	6	0
	1	2	3	4	5	6	7	8	9	10


Grid
TILE
A
B
C
D
E
F
G
H
I
J
K
L
COLUMN
ROW
CELL
BLOCK/STRIP

		Columns						
		0	1	2	3	4	5	6
Rows	0	0	1	2	3	4	5	6
	1	10	11	12	13	14	15	16
	2	20	21	22	23	24	25	26
	3	30	31	32	33	34	35	36
	4	40	41	42	43	44	45	46

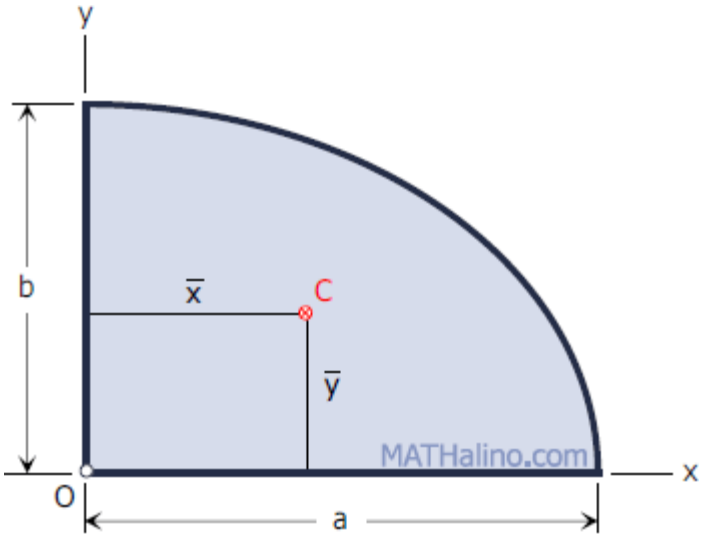
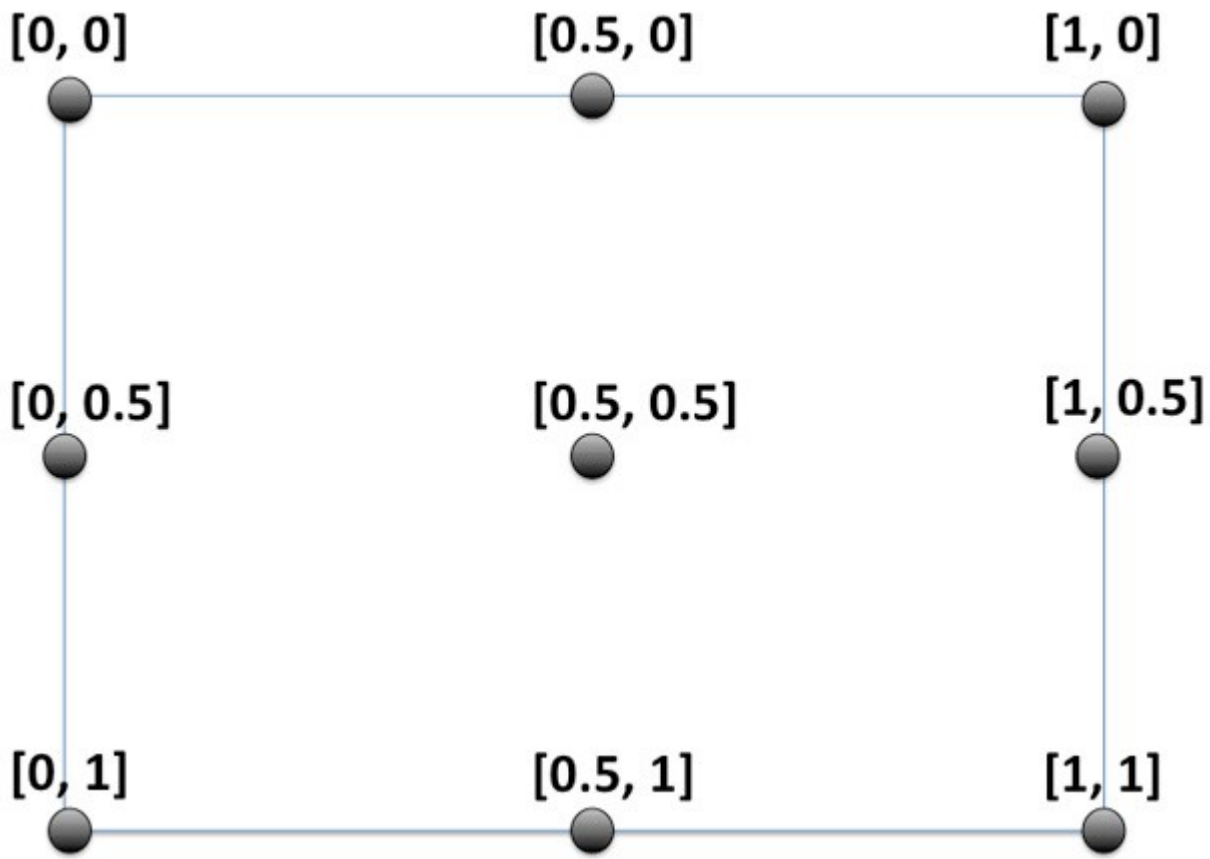


Figure P-707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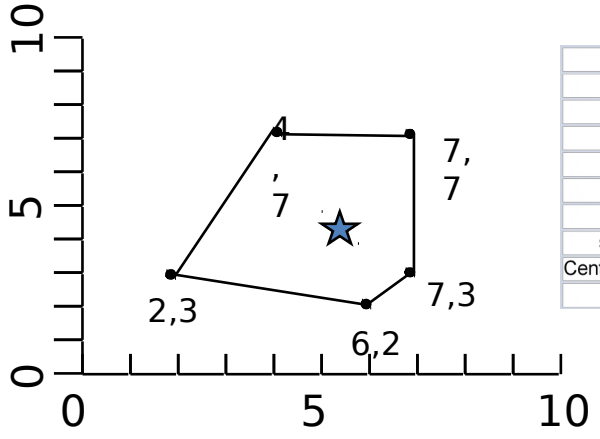
[1, 0]
[0, 0.5]
[0.5, 0.5]
[1, 0.5]
[0, 1]
[0.5, 1]
[1, 1]

When sampling areas are poligonal and irregular

Calculating the **centroid** of a polygon or the **mean center** of a set of points.

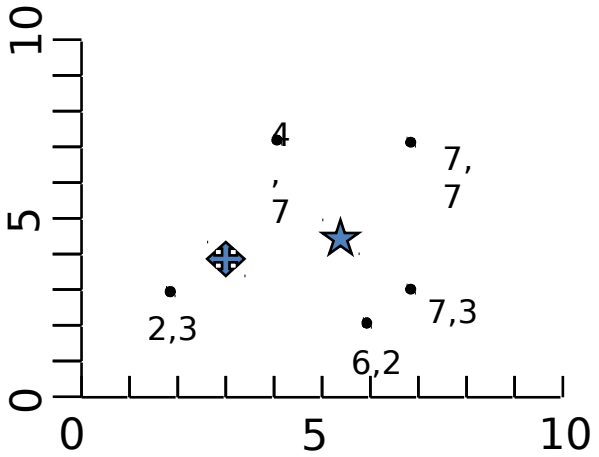


ID	X	Y
1	2	3
2	4	7
3	7	7
4	7	3
5	6	2
sum	26	22
Centroid/MC	**5.2**	**4.4**

(same example data as for area of polygon)

$$\bar{X} = \frac{\sum_{i=1}^{n} X_i}{n}, \bar{Y} = \frac{\sum_{i=1}^{n} Y_i}{n}$$

Calculating the **<u>weighted</u> mean center**. Note how it is pulled toward the high weight point.



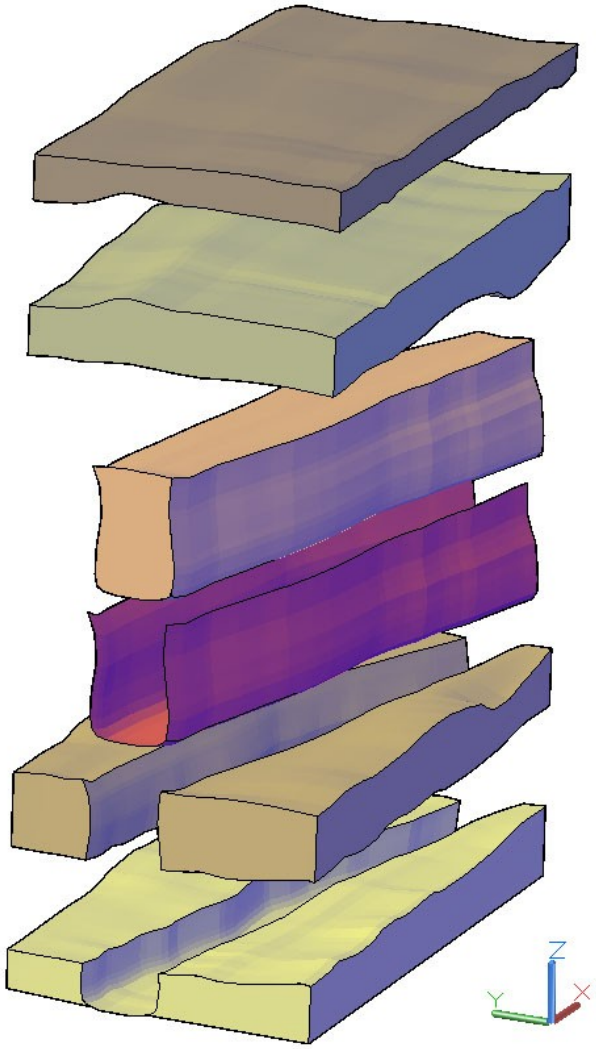
i	X	Y	weight	wX	wY
1	2	3	3,000	6,000	9,000
2	4	7	500	2,000	3,500
3	7	7	400	2,800	2,800
4	7	3	100	700	300
5	6	2	300	1,800	600
sum	26	22	4,300	13,300	16,200
w MC				**3.09**	**3.77**

$$\bar{X} = \frac{\sum_{i=1}^{n} w_i X_i}{\sum w_i}, \bar{Y} = \frac{\sum_{i=1}^{n} w_i Y_i}{\sum w_i}$$

				Global Properties	Global Properties	Particular Properties	Particular Properties
X	***Y***	***Z***	***Time***	***COLOUR***	***PHOSPHATE presence***	***pottery Type A presence***	***Bones (rabitt femur) presence***
1	**2**	**4.5**	**1**	**1**	**yes**	**yes**	**yes**
1.5	**1.6**	**8.7**	**1**	**1**	**yes**	**yes**	**yes**
2,1	**16,1**	**4**	**1**	**1**	**yes**	**yes**	**yes**
4.5	**6.7**	**8.3**	**1**	**1**	**yes**	**yes**	**yes**
3.2	**4.3**	**7**	**1**	**1**	**yes**	**yes**	**yes**
4.1	**2.4**	**1**	**2**	**1**	**yes**	**yes**	**yes**
3.5	**3.5**	**2**	**2**	**1**	**yes**	**yes**	**yes**
1	**1**	**2.3**	**2**	**1**	**yes**	**yes**	**yes**

				Global Properties	Global Properties	Particular Properties	Particular Properties
X	***Y***	***Z***	***Time***	***COLOUR***	***PHOSPHATE COMPOSITION*** ***(parts per thousand)***	***pottery Type A***	***Bones (rabitt femur)***
x_1	y_1	z_1	1	codeRGB	34	1	0
x_2	y_2	z_2	1	codeRGB	56	5	0
x_3	y_3	z_3	1	codeRGB	33	1	1
x_4	y_4	z_4	1	codeRGB	34	0	15
x_5	y_5	z_5	1	codeRGB	32	0	3
x_6	y_6	z_6	2	codeRGB	65	18	8
x_7	y_7	z_7	2	codeRGB	44	1	0
x_8	y_8	z_8	2	codeRGB	66	4	0

3 Dimensional Sampling Areas

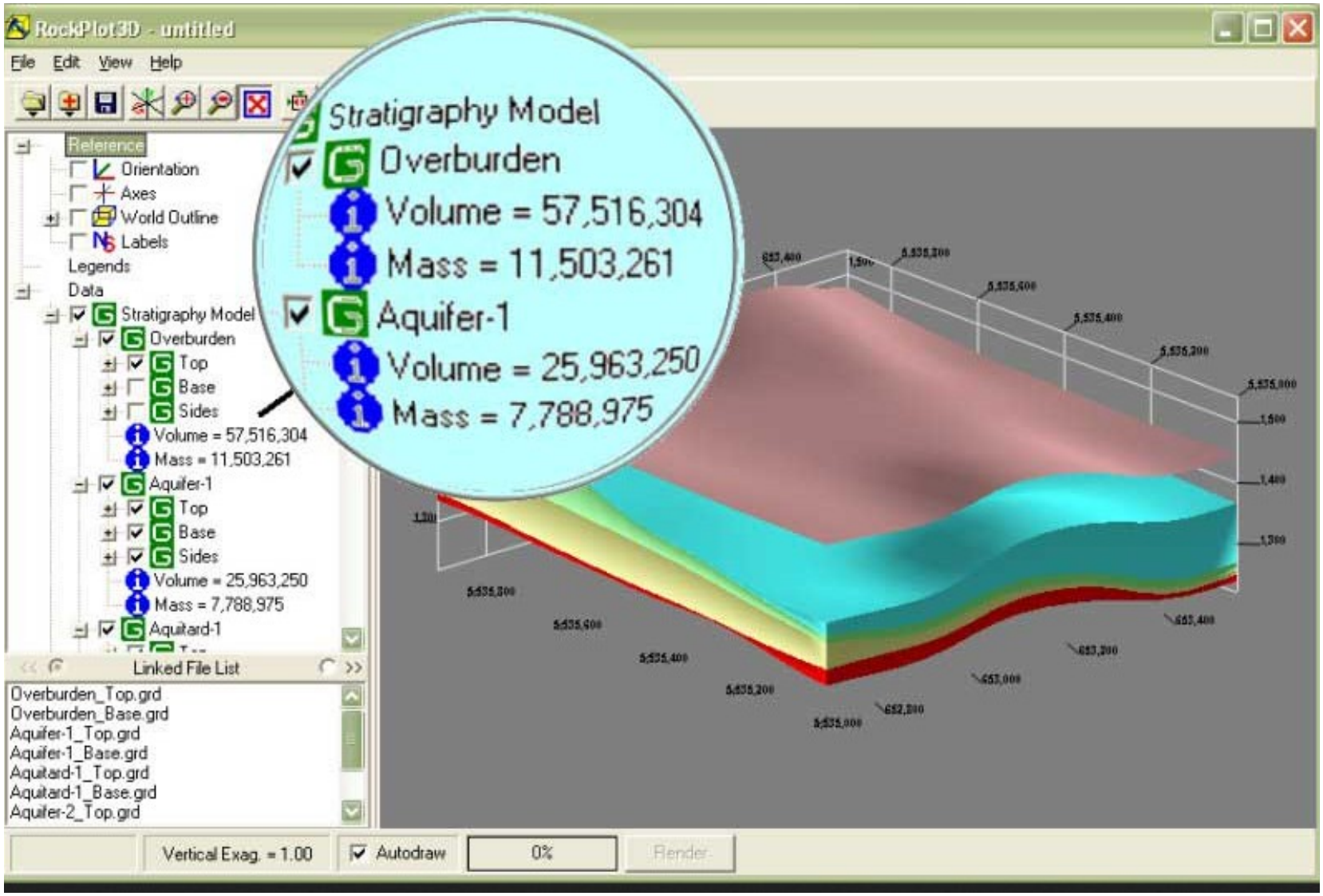


v count observations are not reliable-
need tpo convert count data into spatial frequer
defining sampling units of equal spatial extensio
l temporal duration

; not as easy to stress duration uniformity.

can use stratigraphy, although it is not always
liable as an estimate of duration

3 Dimensional Sampling Areas



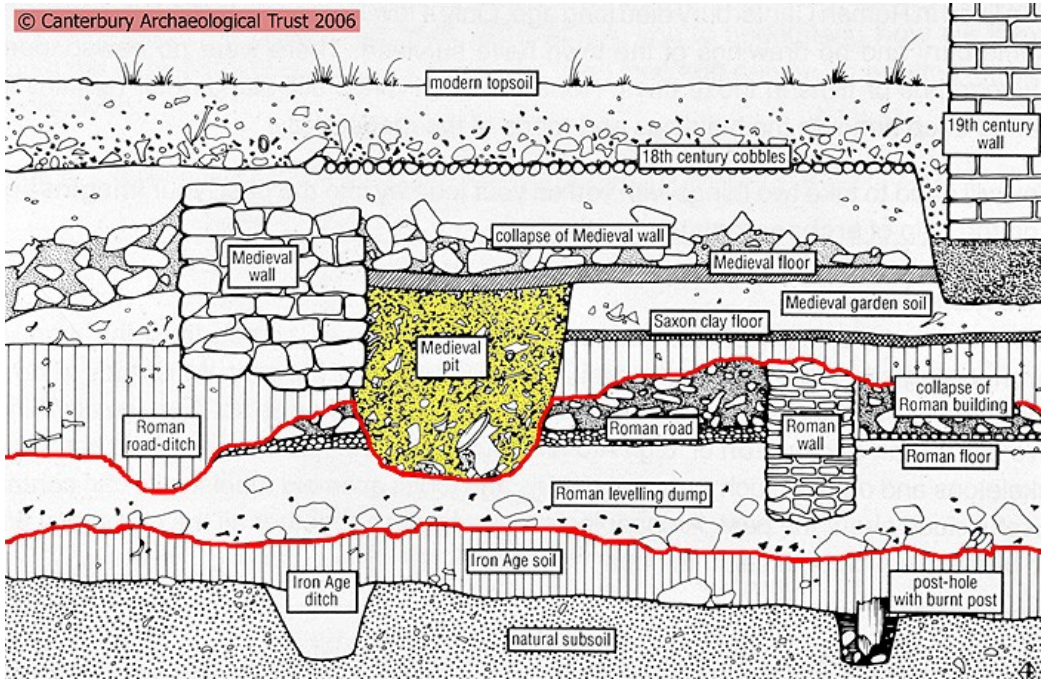
Volumetric calculation. ROCKWORKS.

Measuring Time

Relative?
Absolute?

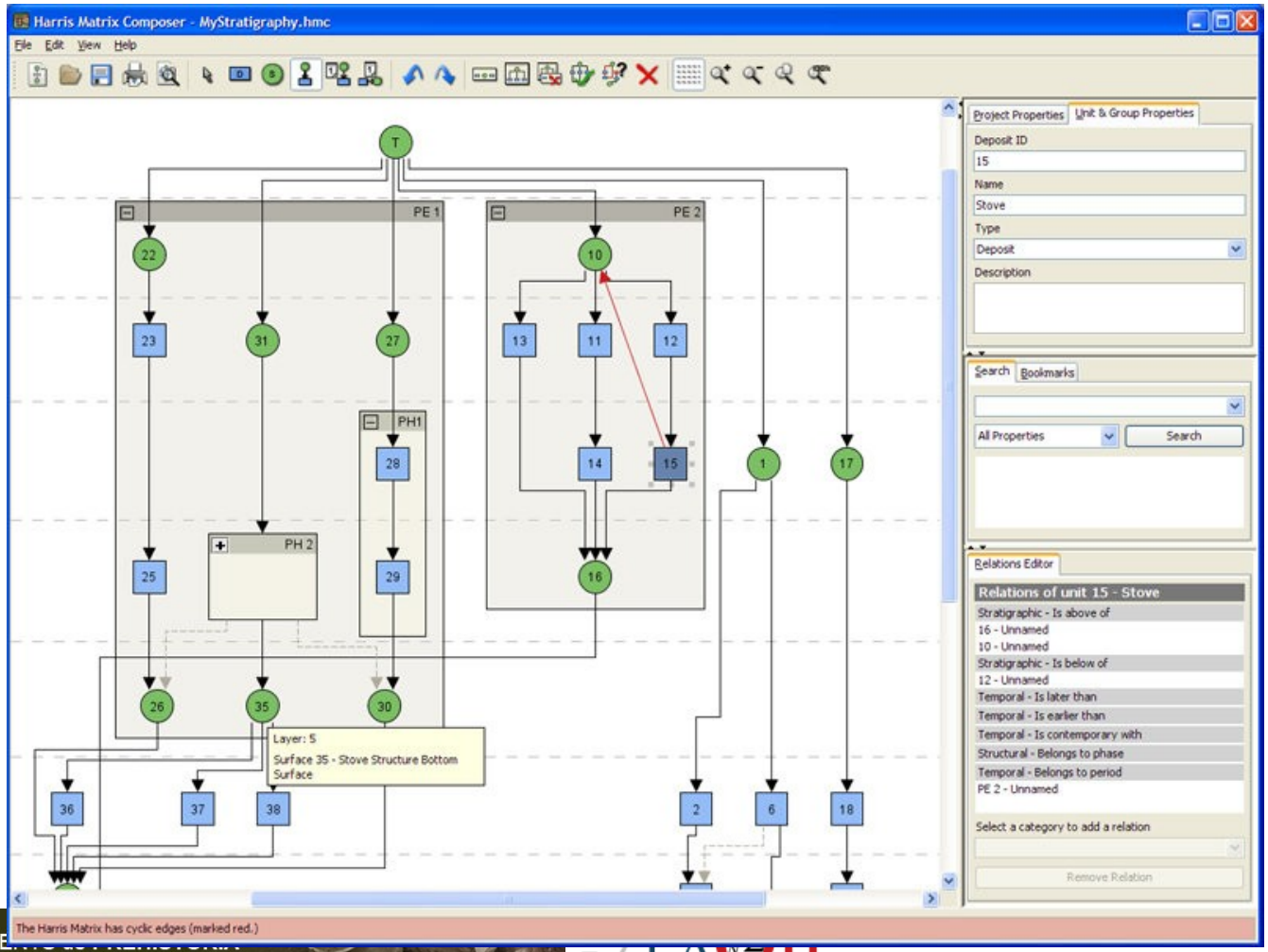
Measuring Time

Relative?



Stratigraphy

http://www.harrismatrixcomposer.com/



Estratigrafia

http://www.stratify.org/index.htm

Stratify 1.5

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Download

History of changes

Links

Acknowledgements

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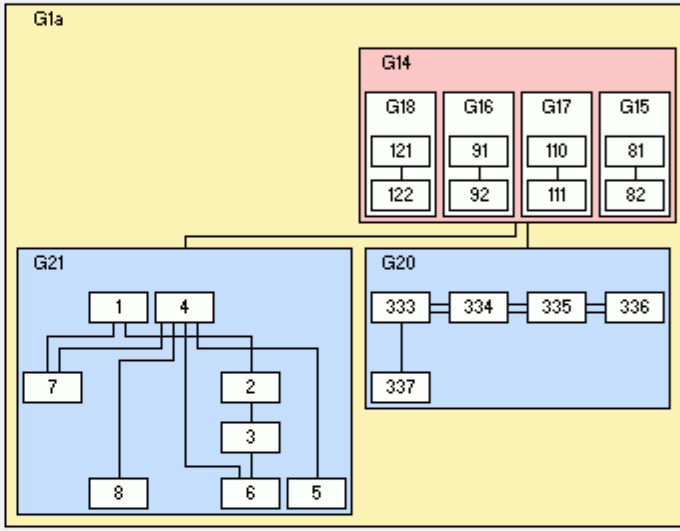
Contact

What is Stratify?

Stratigraphy is a method for relative dating of archaeological contexts. The Harris diagram visualises the relative chronology of a site with a diagram that shows the contexts and their stratigraphic relationships. The aim of the program *Stratify* is to lay out the Harris diagram automatically, taking all the available information on chronology and groupings into account. *Stratify* stores the data of the contexts and their stratigraphic relationships in a data base. Interactive and automatic checks are also supported in order to detect inconsistent, missing, or contradictory relationships.

Features:

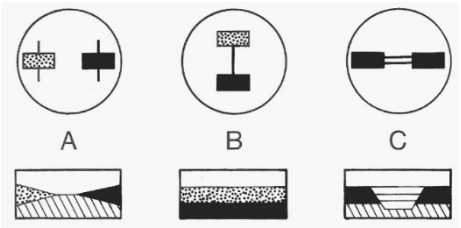
- Unit and relationship data bases
- Displaying phases
- Dealing with groupings
- Thematic box styles
- Term file management
- Coordinate projection
- Interactive and automatic checks
- Combine absolute dates and stratigrgaphic relationships by monotone regression

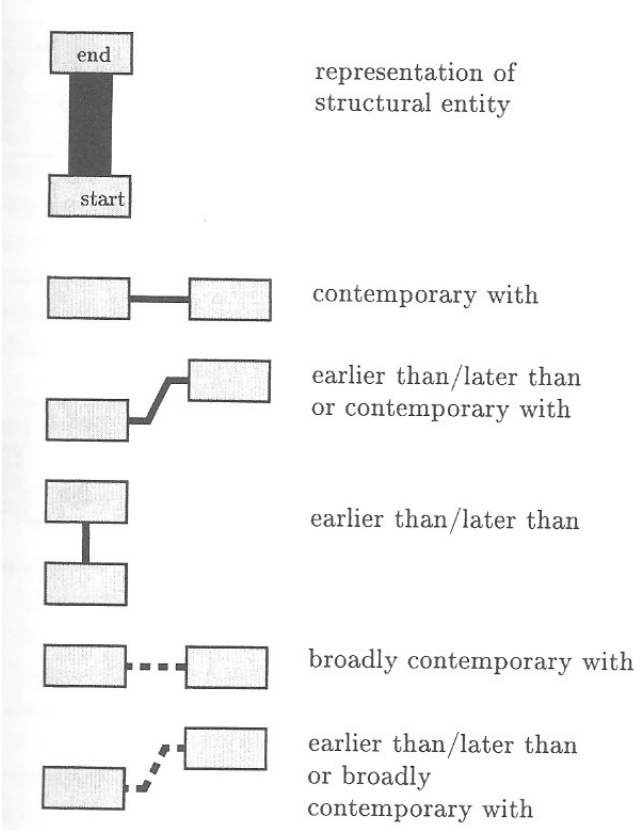


- Output formats: BMP, JPG, DXF, HPGL, MapInfo, SVG, WMF
- Data base import and export formats: csv, DBASE

Measuring Time

Harris Matrix nodes can explain only 3 situations
- Uno es after or before another
- There is no chronological relationship (independence)
- Both are contemporaneous

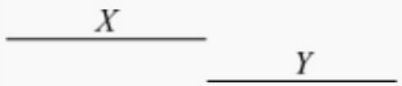
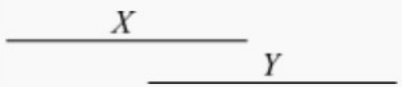
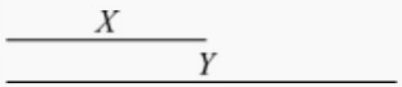
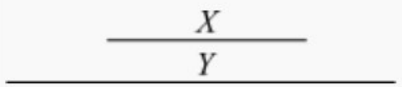
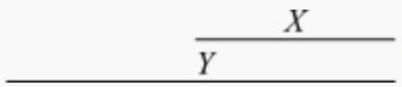
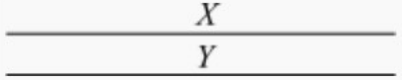




Measuring Time

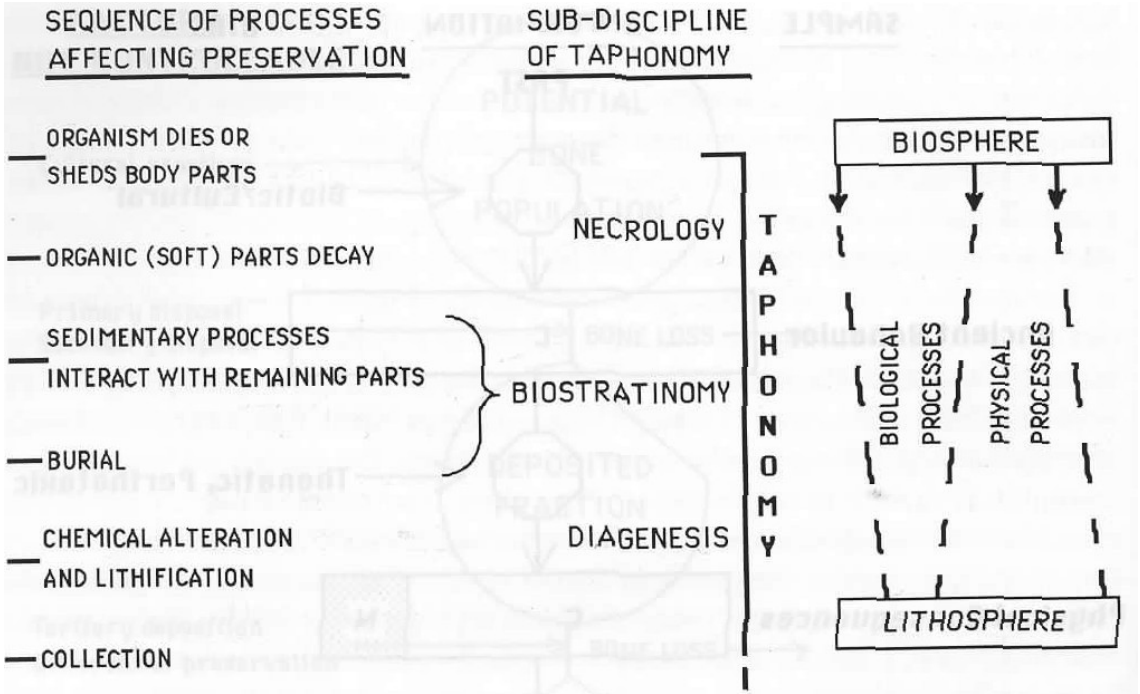
Temporal Reasoning in an Arificial Intelligence domain:
Allen Algebra

The following 13 base relations capture the possible relations between two intervals

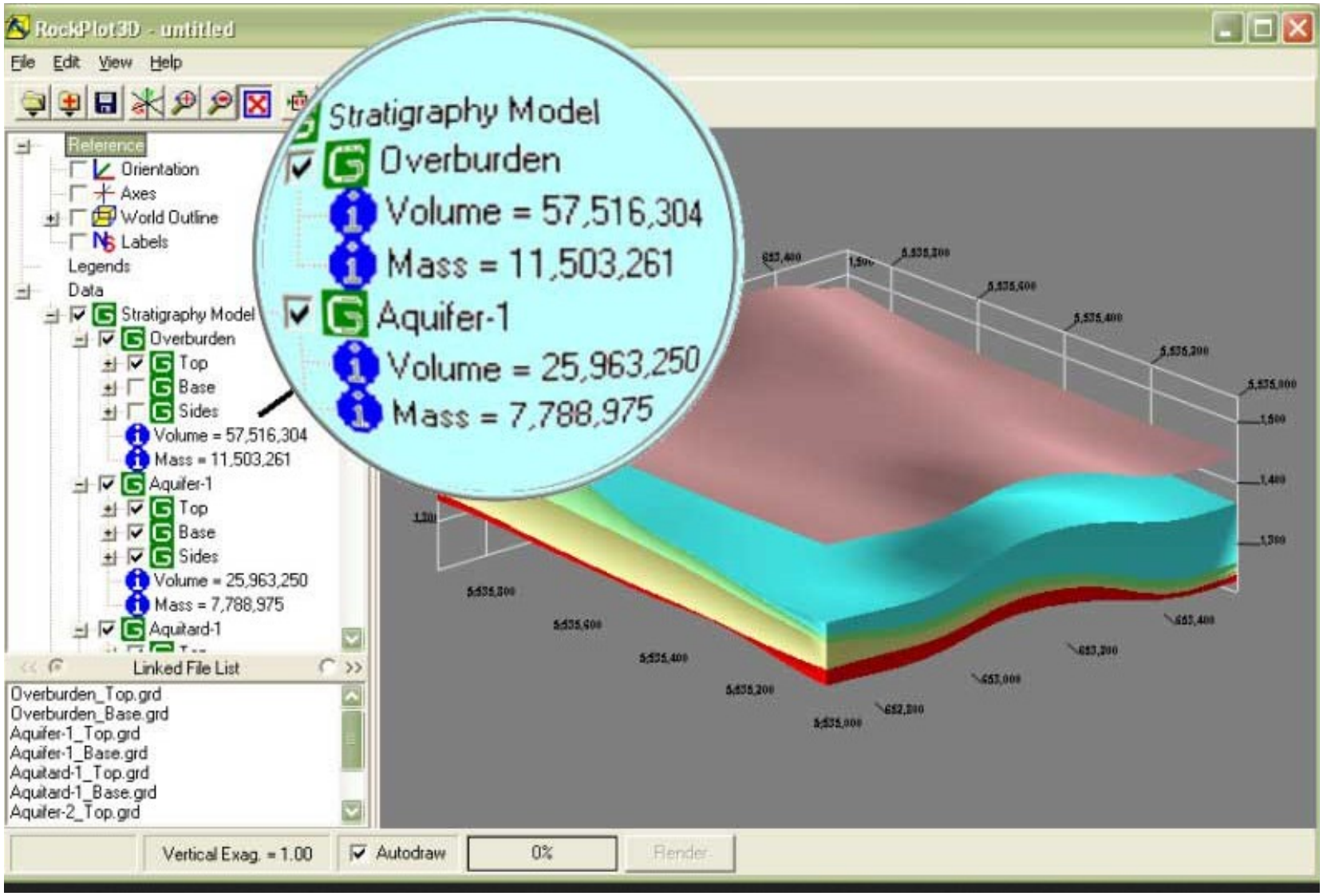
Relation	Illustration	Interpretation
$X < Y$ $Y > X$		X takes place before Y
$X\ \mathbf{m}\ Y$ $Y\ \mathbf{mi}\ X$		X meets Y (*i* stands for ***inverse***)
$X\ \mathbf{o}\ Y$ $Y\ \mathbf{oi}\ X$		X overlaps with Y
$X\ \mathbf{s}\ Y$ $Y\ \mathbf{si}\ X$		X starts Y
$X\ \mathbf{d}\ Y$ $Y\ \mathbf{di}\ X$		X during Y
$X\ \mathbf{f}\ Y$ $Y\ \mathbf{fi}\ X$		X finishes Y
$X = Y$		X is equal to Y

Taphonomy

A relative measure of Temporal Duration

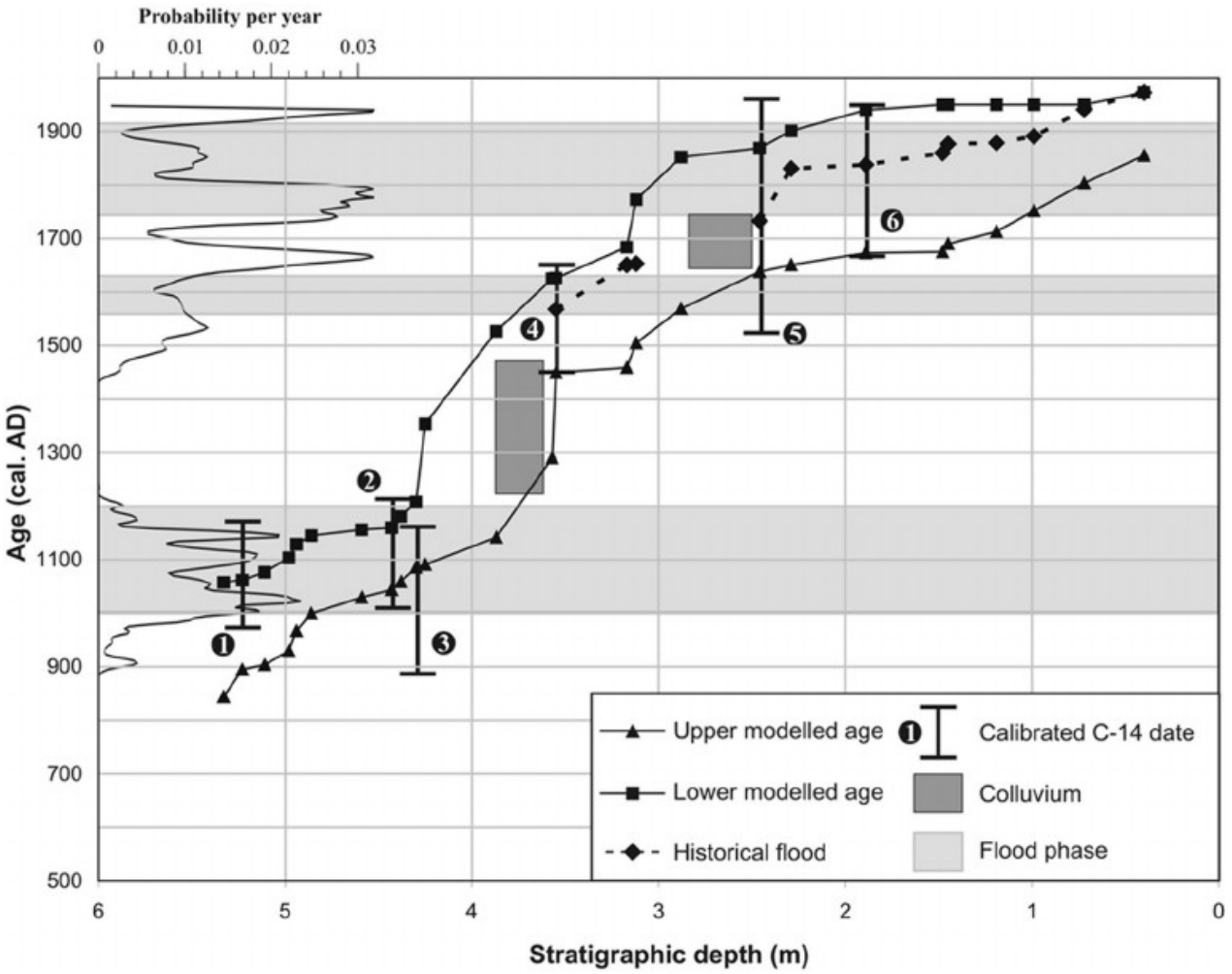


3 Dimensional Sampling Areas



Layer Volume is independent of the duration of formation process.

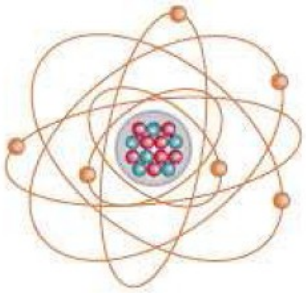
Calculating the time duration of a stratigraphic unit

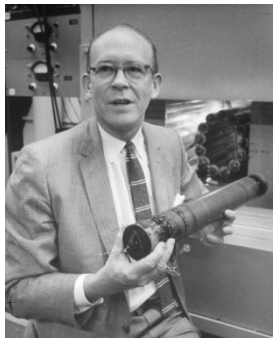


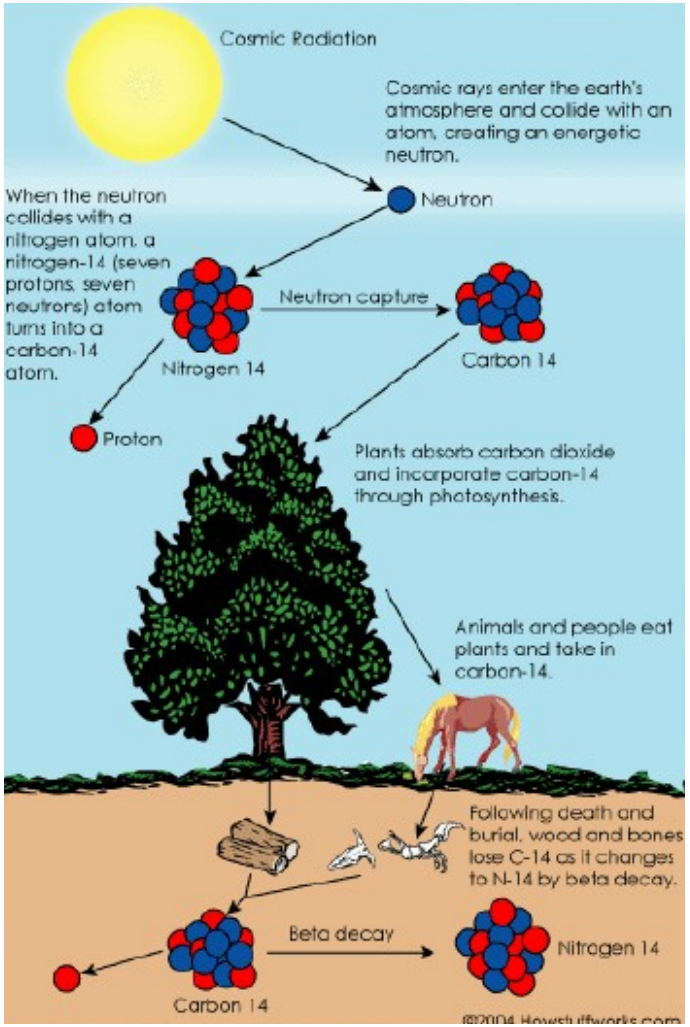
Age-Depth Radiocarbon Modelling

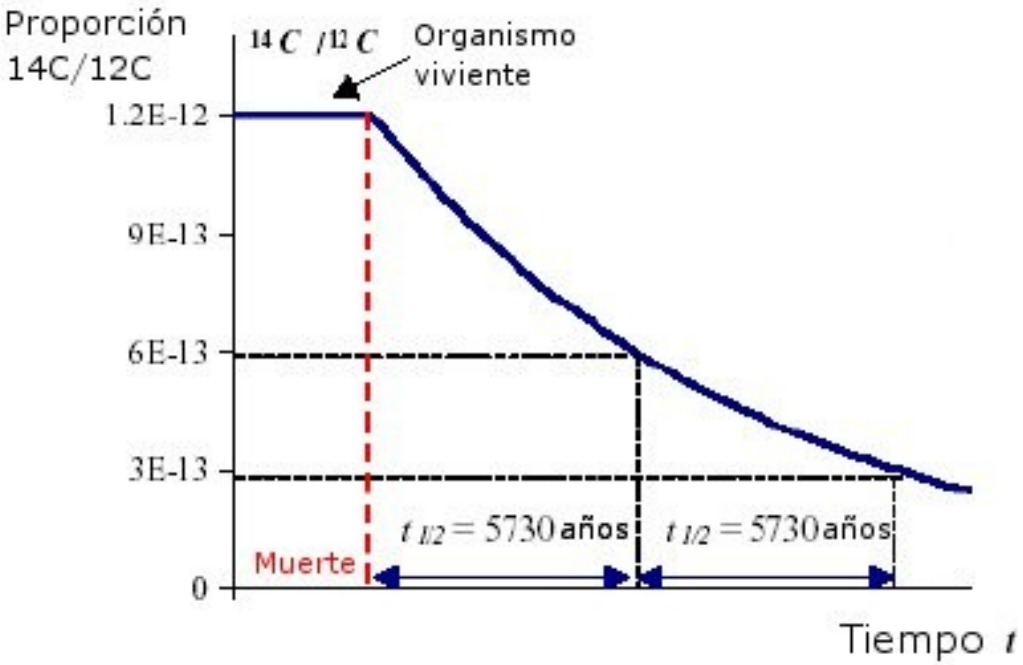
^{14}C An "absolute" measure of time

Introduced in 1946 by W. Libby.



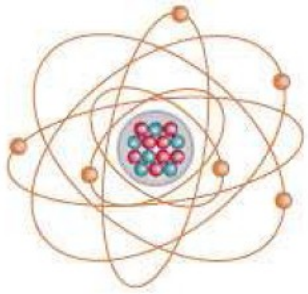


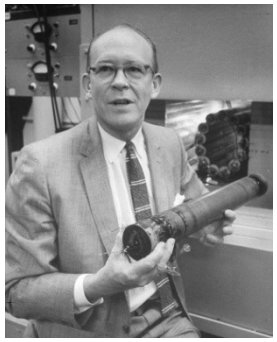


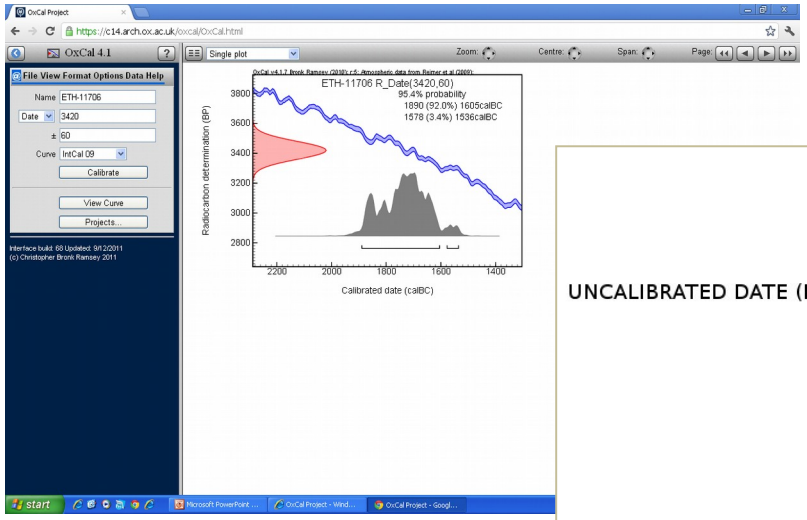


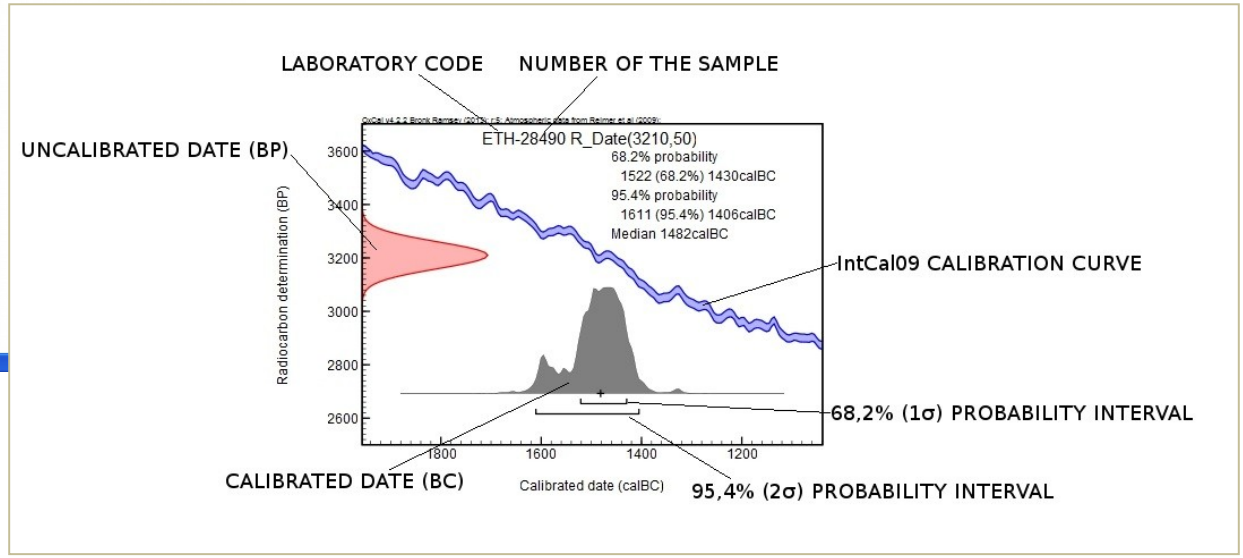
^{14}C An “absolute” measure of time

Although mayber it is not as “absolute” as it may seem.
It is a probabilistic interval, and within it different times moments are possible



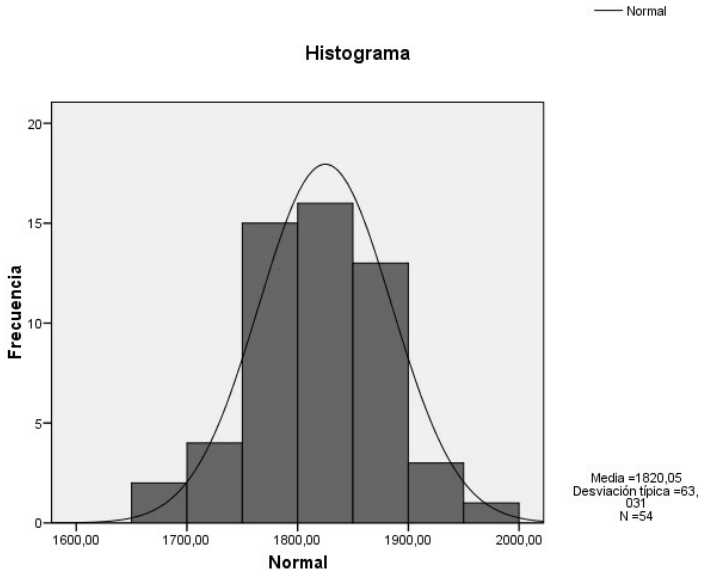






^{14}C An “absolute” measure of time

Measurement error . SIMETRIC (Gaussian, “normal”)

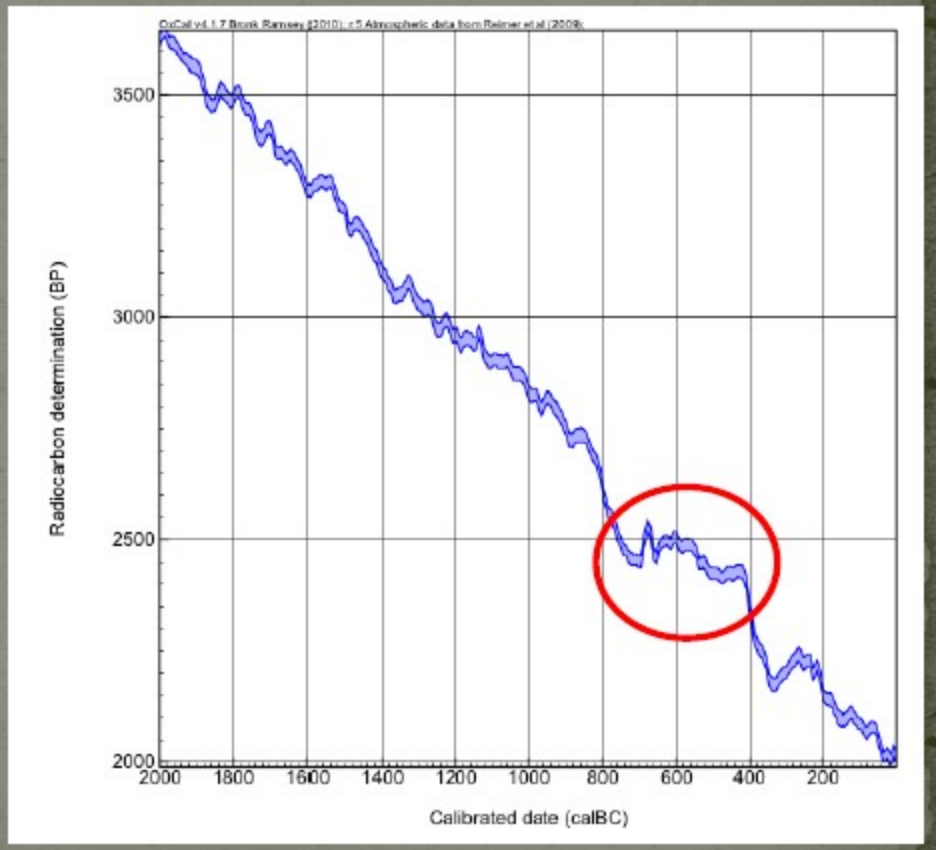


internal statistical error (the counting statistics of the measured total counts, *N*, in the series of measurements) and an external statistical error (comparisons of the error in the mean of a series of n AMS measurements for a sample) have to be introduced. The first error is calculated using the total number of ^{14}C counts measured for each target. The second one is calculated from the reproducibility of multiple exposures for a given target.

The main source for an assumed symmetric (Gaussian) error is produced in the process of radiocarbon dating itself, and it is due to the sample preparation in the laboratory and the probabilistic nature of radioactive decay measurement. The Gaussian error is included in the standard deviation associated to the radiocarbon date, as provided by the laboratories.

LA CURVA DE CALIBRACIÓN

La forma irregular de la curva de calibración condiciona los resultados de la calibración.
A un material no corresponderá tan solo una fecha, sino varias fechas con diferentes grados de probabilidad.
Además, en algunos tramos la curva presenta una forma plana, un ejemplo es la "discontinuidad de Hallstatt" entre 760 y 400 a.C.



COMO SE CONSTRUYE UNA CURVA DE CALIBRACIÓN

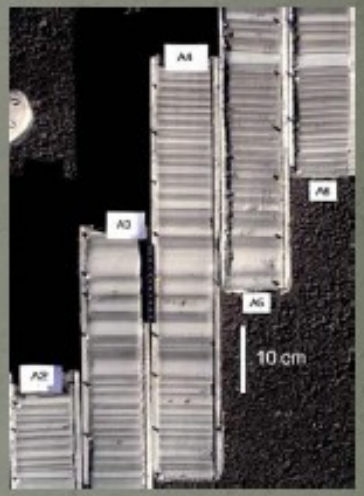
Para corregir una datación ^{14}C hace falta calibrarla.

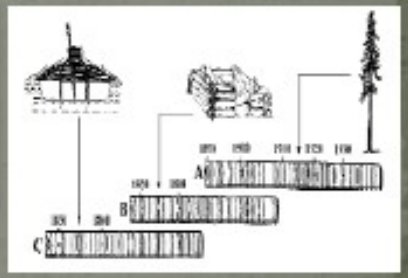
Hoy en día disponemos de curvas de calibración realizadas según 3 métodos:

Hasta 12000 años atrás, datando anillos de arboles cuya edad ya está conocida gracias a la dendrocronología

Hasta 30000 años atrás, datando los corales fósiles a través del método de uranio-torio

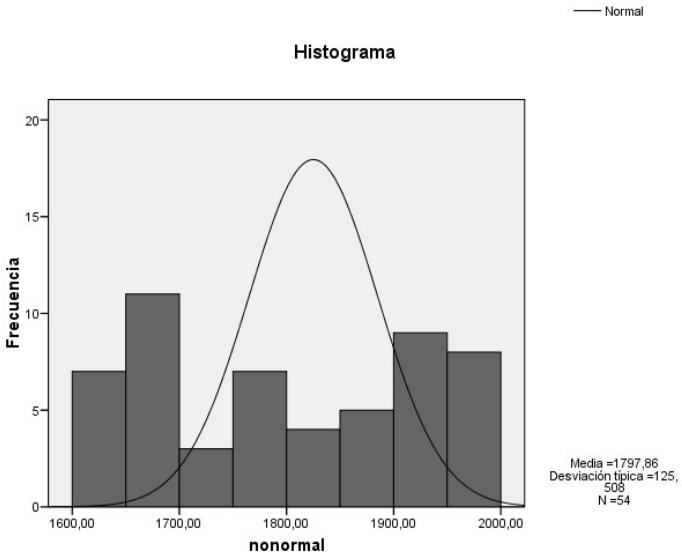
Hasta 45000 años atrás, datando las varvas y las estratificaciones geológicas anuales

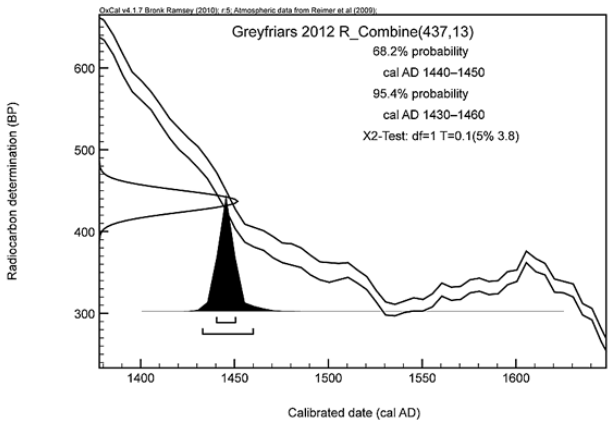




^{14}C Una medida “absoluta” de la Posición de un evento.

2. Calibration. NO-SIMÉTRIC error (non-normal)





The main Non-Gaussian error is due to the calibration curve and the process of calibration. Chemical-physical timescales (isotopic degradation) and astronomical timescales (relative motion earth-sun) are not graded in the same units; therefore, “^{14}C years” are not necessarily the same as the "calendar years” (van Srtrydonck et al. 1999). This is due because the concentration of ^{14}C has not been uniform all along the time span of the astronomical scale (Aitken 1990, Bowman 1990)

PROGRAMAS DE CALIBRACIÓN

Existen varios programas que nos permiten calibrar una datación radiocarbónica:

OxCal (http://c14.arch.ox.ac.uk/)

Bcal (http://bcal.shef.ac.uk/)

CalPal (http://www.calpal.de/)

Calib (http://calib.qub.ac.uk/calib/)

LA FIABILIDAD DE UNA DATACIÓN ^{14}C

Una datación radiocarbónica, debido a su valor probabilístico, se caracteriza por tener un nivel de incertidumbre. Por lo tanto, hace falta reconocer esta incertidumbre a través de un control del error que se puede introducir en las diferentes fases del proceso de datación.

ERRORES EN LA TOMA DE DATOS

ERRORES DEL LABORATORIO

CALIBRACIÓN

ERRORES EN LA TOMA DE DATOS

Hay que tener cuidado con los fenómenos de bioturbación y la actividad humana que pueden desplazar las posibles muestras.

Los **mejores contextos** son:

1. Estratos en deposición primaria y que representen eventos de corta duración (p.ej. nivel de destrucción, pavimento, hogar, etc.)
2. Estratos identificados por una conjunto cerámico seguro
3. Acumulaciones de semillas o de carbones en un mismo sitio(p.ej. en una vasija)
4. Clara asociación de las muestras con estructuras más grandes (p.ej. carbones en un hogar o en un horno)
5. Huesos en articulación. Los huesos largos, además de preservar mejor el colágeno, son más difíciles de desplazar.

LAS MUESTRAS

A través del análisis de la cantidad de ^{14}C presente en los restos orgánicos se pueden datar materiales entre 200 y ca. 50000 años atrás.

Las posibles muestras se dividen en dos categorías:

- Muestras de vida larga (carbón vegetal, madera)
- Muestras de vida corta (semillas, frutos, huesos humanos y animales, dientes, cuernos)




LAS MUESTRAS DE VIDA LARGA

- Carbón
- Madera

Efecto madera antigua → Datamos el momento en el que el organismo interrumpió el intercambio de ^{14}C con la atmósfera y no el momento de uso de la madera que registramos a nivel arqueológico.

La fecha obtenida es un *terminus post quem*.

LAS MUESTRAS DE VIDA CORTA

- Semillas y frutos
- Huesos humanos y animales (colágeno)

Teniendo un ciclo de vida mucho más breve que las muestras de vida larga, se caracterizan por ser mucho más fiables.

(Técnicas de medición)

Actualmente existen dos técnicas para medir la concentración de $^{14}C/^{12}C$ de una muestra.

Método de Libby

- Método tradicional para medir la radiactividad ß (electrones producidos) de la muestra

Método AMS

- Basado en la Espectrometría de Masas con Aceleradores (EMA), no detecta la radiación emitida por los núcleos, sino que se cuentan directamente los núcleos de interés de la muestra.

VENTAJAS DE UNA DATACIÓN AMS

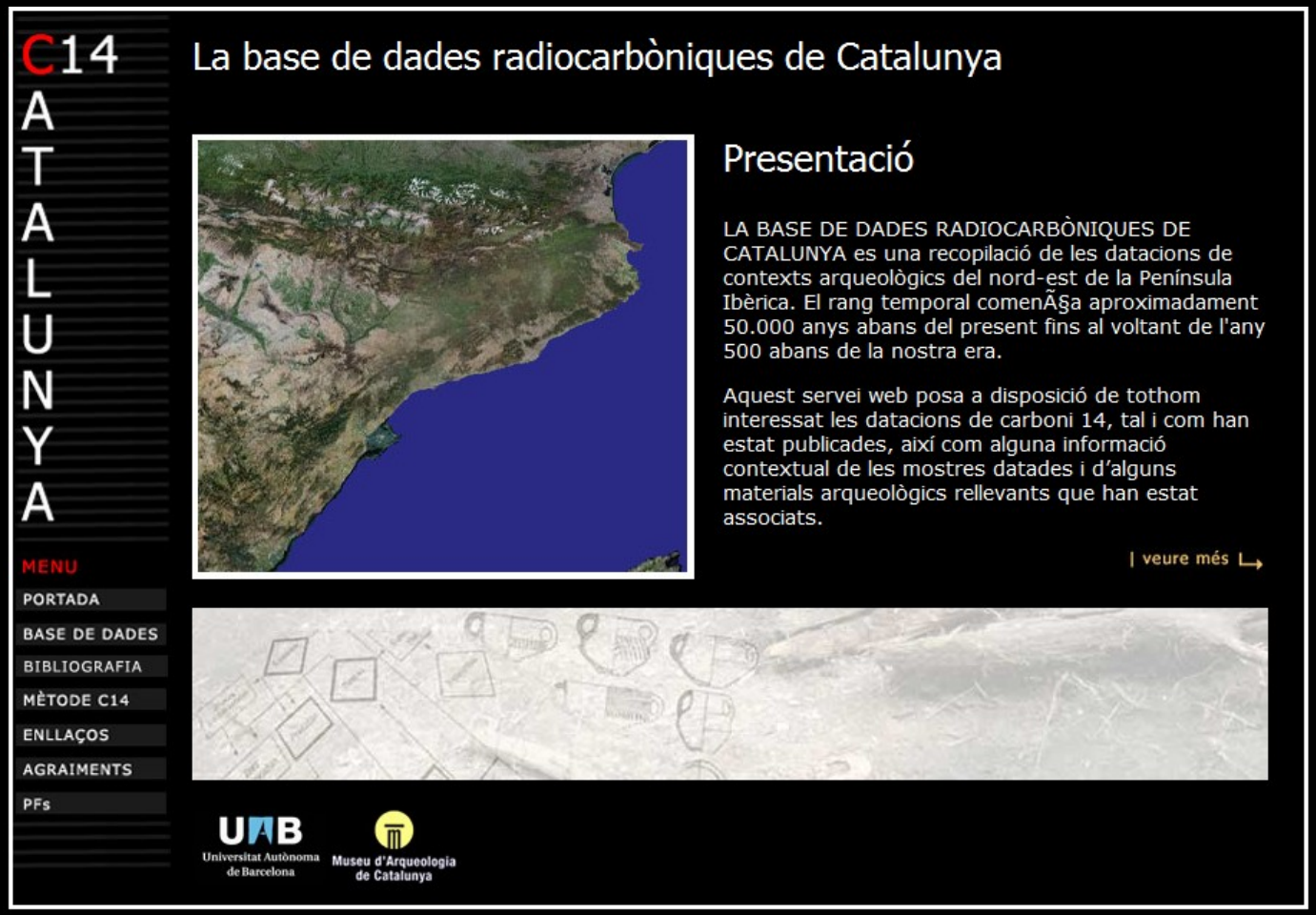
La medida es mucho más sensible, se caracteriza por una desviación estándar inferior a la obtenida a través del método tradicional

Es mucho más rápida (ca. 30 m.): se mide directamente la concentración de ^{14}C y no hace falta esperar a que los átomos decaigan

Las muestras son mil veces más pequeñas (mg) que las de método tradicional, eso implica una mejoría en la preparación de las muestras eligiendo tan solo las zonas con menor contaminación

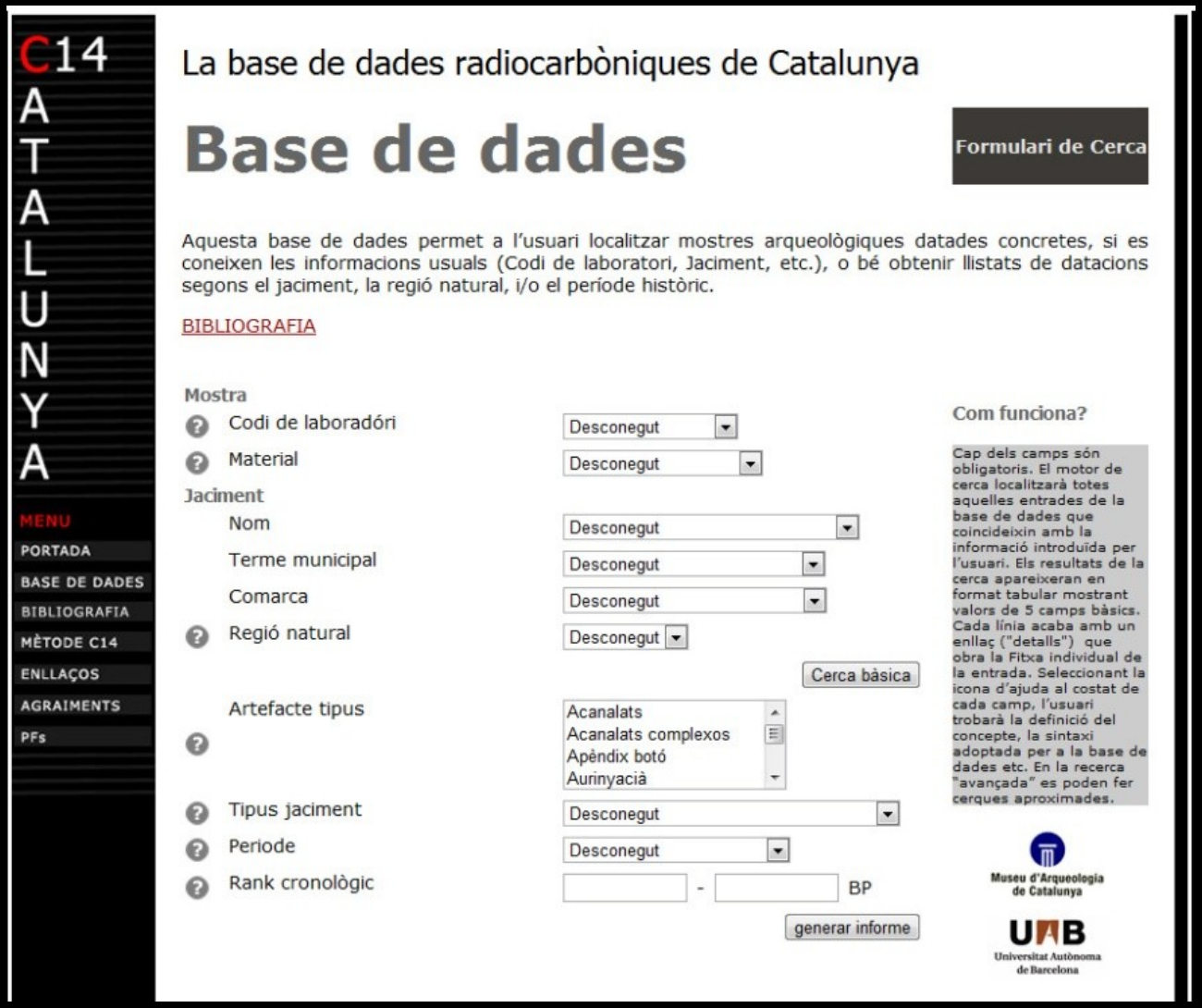
Oxford Radiocarbon Accelerator Unit

LA BASE DE DATACIONES ^{14}C DE CATALUÑA
http://www.telearchaeology.com/c14



La base de datos de dataciones C14 para la prehistoria de Catalunya esta realizada como un primer paso hacia un modelo, complejo de la cadena de inferencia des del evento isotópico hasta evento social, y representa actual estado de cuestión.

EL EVENTO ISOTÓPICO COMO PUNTO DE PARTIDA



LA BASE DE DATACIONES DE CATALUÑA

http://www.telearchaeology.com/c14/

C14 CATALUNYA

MENU
PORTADA
BASE DE DADES
BIBLIOGRAFIA
MÈTODE C14
ENLLAÇOS
AGRAIMENTS
PFs

La base de dades radiocarbòniques de Catalunya

Base de dades

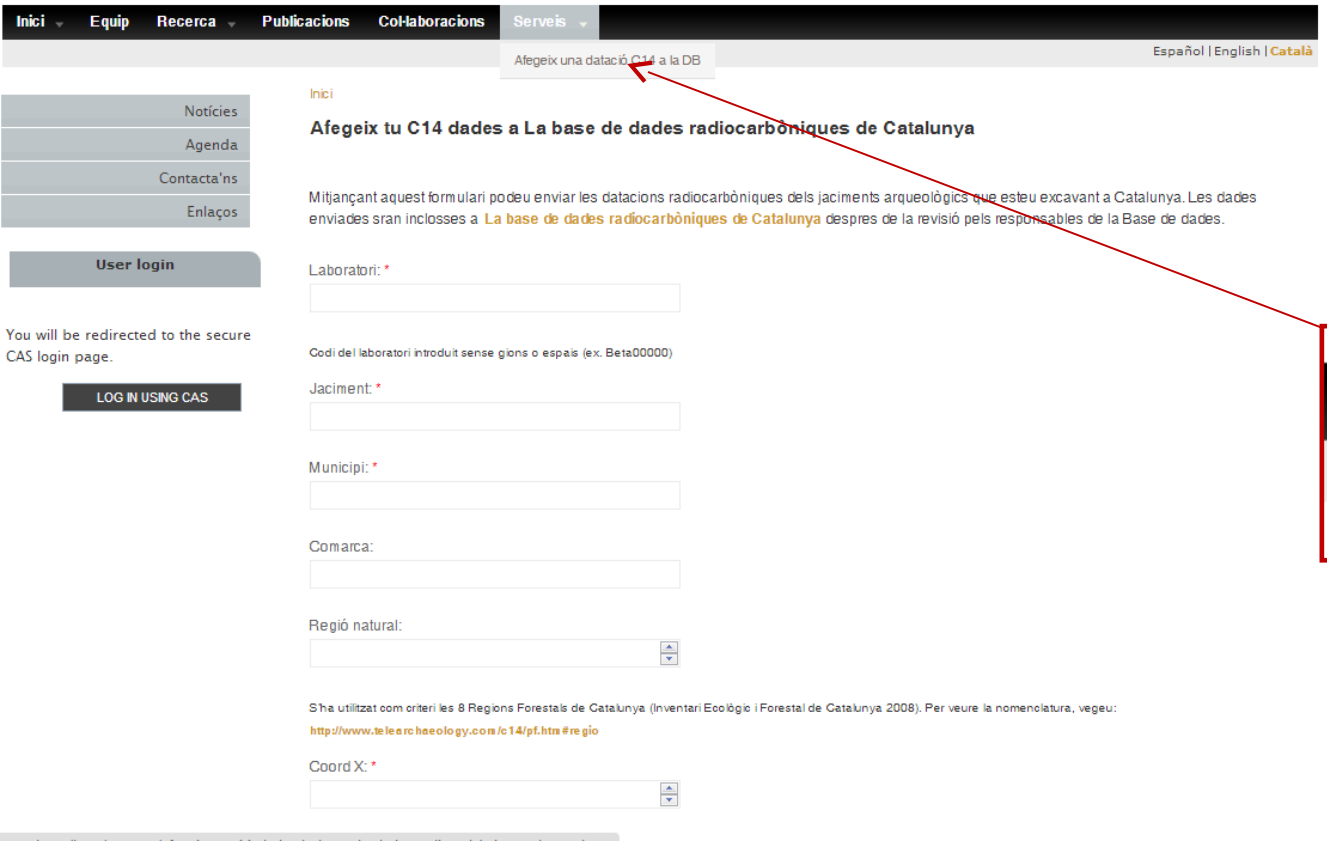
Resultats de la cerca:

Laboratori	Jaciment	Municipi	Edat BP	Material	Cronologia	
Beta61505	Balma del Serrat del Pont	Tortellà	2450	Carbó	Bronze Final A	Detalls
UBAR180	Balma del Serrat del Pont	Tortellà	3530	Carbó	Bronze Final A	
UBAR181	Balma del Serrat del Pont	Tortellà	3160	Carbó	Bronze Final A	Detalls
Beta98213	Barranc de Gàfols	Ginestar	2770	Carbó	Bronze Final B	Detalls
Poz18861	Camp dels Moros de la Codina	Pinell	2885	Os animal	Bronze Final B	Detalls
Poz18862	Camp dels Moros de la Codina	Pinell	2850	Os animal	Bronze Final B	Detalls
UBAR850	Can Gambús 2	Sabadell	2925	Carbó	Bronze Final B	Detalls
UBAR851	Can Gambús 2	Sabadell	2850	Carbó	Bronze Final B	Detalls
UBAR675	Can Roqueta II	Sabadell	2530	Carbó	Ferro I A	Detalls
UBAR674	Can Roqueta II	Sabadell	2735	Carbó	Bronze Final B	Detalls

First Previous Next Last 65 entrades

ID	53
Laboratori	UBAR180
Jaciment	Balma del Serrat del Pont
Municipi	Tortellà
Comarca	Garrotxa
Regió	2
Provincia	Girona
Regió geogràfica	Prepirineu (Vall mitjana Fluvià)
Coord. X	467493
Coord. Y	4677516
Any datació	1990
Edat BP	3530
Desviació Típica	90
Limite Inferior 95	2132
Limite Superior 95	1632
Limite Inferior 68	1990
Limite Superior 68	1750
Material	Carbó
Procedència	Nivell II.2b (prop llar AC1) ocupació
Objectetipus	Tasses carenades, Acanalats
Context funcional	Residencial
Tipus Jaciment	Abric
Cronologia	Bronze Final A
Bibliografia	Alcalde, G.; Molist, M. i Toledo, A. (1994), p. 81
OBSERVACIONS	
AMS	

Laboratori d'Arqueologia Quantitativa

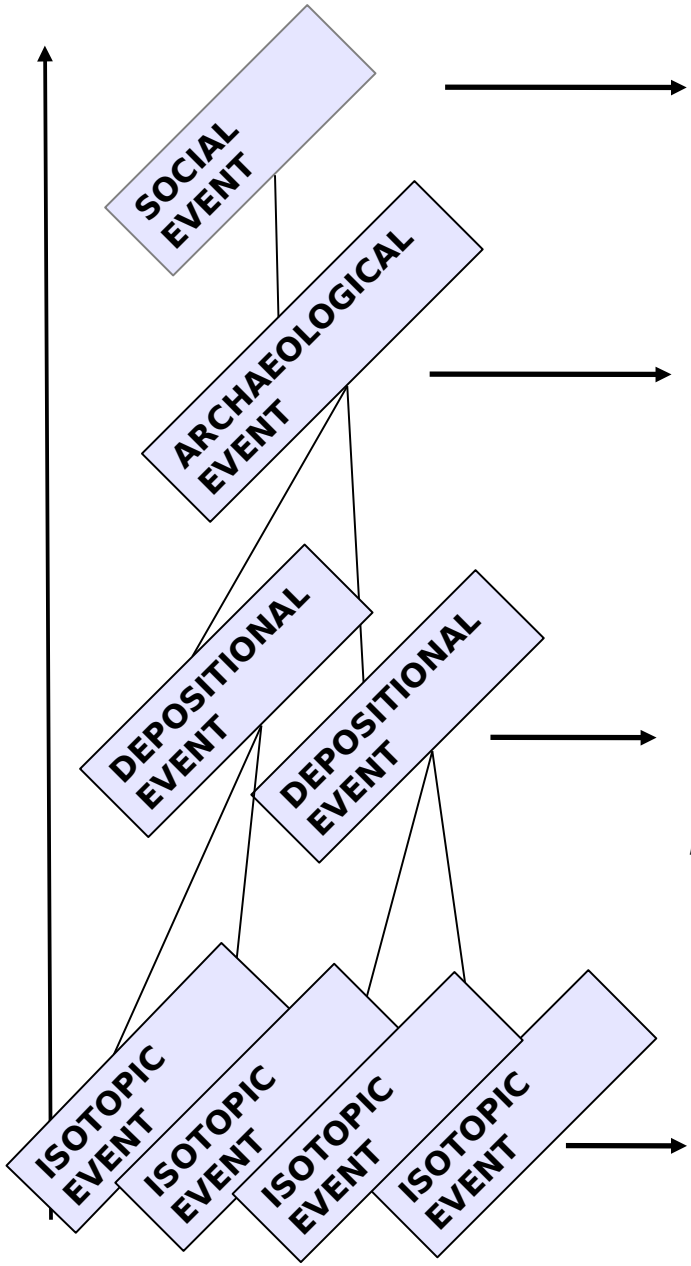


A través de este formulario podéis enviar les dataciones radiocarbónicas de los yacimientos arqueológicos que estáis excavando a Catalunya. Los datos enviados serán incluidos a **La base de dades radiocarbòniques de Catalunya** después de la revisión per responsables de la Base de datos.

La cadena de la inferència espaciotemporal

Eventos isotópicos → Eventos deposicionales → Eventos arqueológicos → Eventos sociales

FROM ARCHAEOLOGICAL INFORMATION TO HISTORICAL KNOWLEDGE: a palimpsest structure

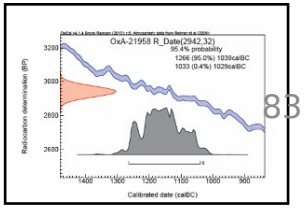


The social action which produced the material evidence in the archaeological record.

Material consequences of social actions that happened in the past, it can be composed by many different particular depositional events, with different calendar dates and different durations.

The particular action that generated the location of such item at this particular place and moment.

The result of a radiocarbon dating: the particular moment in which a living being -animal or plant- ceased to interact with the atmosphere and biosphere.



MUESTRA DATADA: Corresponde a la materialidad de un suceso isotópico (Coordenadas cartesianas locals (0.0 local)

CONTEXTO INMEDIATO: Corresponde a la materialidad de un suceso depositacional y el suceso arqueológico al que se refieren varios sucesos depositacionales contemporáneos relacionados causalmente. En la práctica está formado por los materiales arqueológicos inmediatamente vinculados (espacial y tafonómicamente) con la muestra datada. Unidad Mínima de la intervención arqueológica.

CONTEXTO RELACIONADO: Corresponde a la materialidad de sucesos arqueológicos causalmente relacionados con el que generó la muestra, tanto espacial como temporalmente. En la práctica está formado por los materiales arqueológicos no-inmediatamente vinculados (espacial y tafonómicamente) con la muestra datada, pero sí relacionados de modo tal que la relación pueda expresarse en términos espaciales y temporales. Si no es posible la relación espacio-temporal, el contexto secundario no será reconstruible. Asociación estratigráfica de Unidades Mínimas de intervención arqueológica.

CONTEXTO GLOBAL DE LAS RELACIONES ARQUEOLOGICAS DE LA MUESTRA. Informaciones generales inferibles a partir de las relaciones contextos secundarios. (UTM del jaciment dins el qual es delimita el ext secundaria)

MUESTRA DATADA
Codigo Laboratorio
METODO DE DATACION
Vida Media de la muestra
Código Arqueológico de Muestra
Fecha de Excavación
Fecha de Obtención y Análisis de la muestra
Tipo intervención Arqueológica: excavación urgencia, excavación sistemática, fondo de museo, prospección, hallazgo accidental
Coordenadas Espaciales (x,y,z) en el sistema local no georeferenciado.
Tipo de muestra: Hueso No Carbonizado, hueso carbonizad, carbón, Semilla Carbonizada, Semilla no carbonizada madera-no-carbo,
Materia de la muestra
Taxonomia de la muestra
Porcentaje Carbón Marino
BP SD D13C D13SD DeltaR DeltaR SD
CALIBRACION: Curva
Extremo inferior intervalo 1s
Extremo superior intervalo 1s
Extremo inferior intervalo 2s
Extremo superior intervalo 2s
Referencia bibliográfica en la que aparece publicado el análisis cronométrico de la muestra
VALORACION DEL RESULTADO CRONOMÉTRICO (%). Calculado automáticamente por la Base de datos: 100% = Vida Media de la Muestra < 10 años; Método de datación: AMS; SD<40; Diferencia Extr.Sup.-Extr.Inf. 1s < 75

CONTEXTO PRIMARIO:
Etiqueta de Contexto primario: En el formato en el que haya aparecido publicada (Unidad Estratigráfica | Estructura |)

LOCALIZACION DE LA MUESTRA EN LA UNIDAD ARQ. DE REFERENCIA: Ubicación central, Ubicación próxima al centro, Ubicación marginal o periférica
Tipo de Contexto: hallazgo aislado, hallazgo dentro de contenedor individualizado, tumba, suelo de ocupación, área de actividad, agujero de palo, hogar, silo, fosa de construcción, matriz sedimentaria, acumulación no definida, ...
Caracterización del Contexto: Cerrado, Abierto, Sin límites definidos...
TAFONOMIA: Primario (fase constructiva), Secundario (uso después de construcción), Abandono, Post-depositacional (amortización después del uso primario y/o secundario)

FUNCIONALIDAD DEL CONTEXTO PRIMARIO: CAMPO DE VALOR ÚNICO: Funerario, Ritual No-Funerario, Residencial, almacenamiento, estabulación animal, producción de útiles, producción de subsistencias, defensa, ...

ARTEFACTO-TIPO RELACIONADO EN CONTEXTO PRIMARIO: punta magdaleniense IV, cerámica cardial, vaso campaniforme, Argar Forma 6, punta palmela, espada de lengua de carpa, Dragendorff 2ª, Anfora púnica tipo Ramon 2. Sigillatta sudgálica, etc.

VALORACIÓN DE LA RELACIÓN CONTEXTUAL PRIMARIA (%)]. Valor calculado por la base de datos como resultado de la caracterización del depósito: 100%= localización= central; caracterización contexto= cerrado; tafonomia= Primaria.

CONTEXTO SECUNDARIO:
Etiqueta de Contexto Secundario: En el formato en el que haya aparecido publicada (Nivel Arqueológico / Fase de Ocupación
YACIMENTO ARQUEOLOGICO
georeferenciación se definirá por medio de cuatro columnas: huso, zona, x, y.
LOCALIZACION JACIMENT ARQUEOLOGIC 1: Termino Municipal (Nomenclatura Administrativa Oficial)
LOCALIZACION JACIMENT ARQUEOLOGIC 2: Región Natural.
RELACION ESTRATIGRAFICA ENTRE LOS CONTEXTOS PRIMARIOS QUE DEFINEN EL CONTEXTO SECUNDARIO: DIRECTA, INDIRECTA. Si no hay relación estratigráfica de contigüidad/contemporaneidad, el contexto primario no tendrá vinculación a contexto secundario alguno.
Tipo de Contexto Secundario: tumba, necrópolis, silo, suelo de ocupación, estructura construida, área de actividad, poblado, no definido
Funcionalidad Contexto Secundario: CAMPO DE VALOR MULTIPLE (todas las funciones identificadas en los distintos contextos primarios que definen el secundario): Funerario, Ritual No-Funerario, Residencial, almacenamiento, estabulación animal, producción de útiles, producción de subsistencias, defensa, …
ARTEFACTO-TIPO RELACIONADO EN ALGUNO DE LOS CONTEXTOS PRIMARIOS QUE CONFIGURAN EL CONTEXTO SECUNDARIO: punta magdaleniense IV, cerámica cardial, vaso campaniforme, Argar Forma 6, punta palmela, espada de lengua de carpa, Dragendorff 2ª, Anfora púnica tipo Ramon 2. Sigillatta sudgálica, etc.
VALORACIÓN DE LA RELACIÓN CONTEXTUAL SECUNDARIA (%)]. Valor calculado por la base de datos como resultado de la caracterización del depósito: 100%= Relación Estratigráfica= Directa; Más de tres Contextos Primarios datados y [illegible]nados; Diferencia Cronológica entre todas las muestras datadas de un mismo [illegible]o Secundario (distintos contextos primarios) inferior a 75 años.

CONTEXTO HISTORICO:

PERIODO: Paleolítico Superior, Mesolítico, Neolítico, Calcolítico, Bronce Antiguo, Bronce Final IIIb, Hierro Antiguo I, Romano Altorepublicano, Baja Edad media Tardía,...

CULTURA ARQUEOLOGICA: Argar, vaso Campaniforme, megalitismo, Sepulcros de Fosa, cardial, Post-Cardial, EpiCardial, Proto Talayótico, Romano, Mozárabe,....

ESTRATEGIAS ECONOMICAS REGISTRADAS DURANTE EL PERIODO HISTORICO: CAMPO DE VALOR MULTIPLE: caza, recolección, agricultura, ganadería, metalurgia (cobre, bronce, oro, hierro), intercambio, comercio...

ESTRATEGIAS SOCIO-POLÍTICAS REGISTRADAS DURANTE EL PERIODO HISTORICO: CAMPO DE VALOR MULTIPLE: bandas, jefaturas, estado, clases_sociales, despotismo, imperialismo, independencia...

Mompou - Musica Call... | CONGRESO – Iber-Crono

ibercrono.org/?page_id=20

temporal duration

Iber-Crono

Cronometrías para la historia de la Península Ibérica

Inicio CONGRESO BASE DE DATOS CURSOS Inscripción

Inicio→*CONGRESO*

Iber-Crono
Congreso

Barcelona 2016

INDICE

ESPACIO USUARI@S

CONGRESO

Cronometrías Para la Historia de la Península Ibérica

Barcelona, 17-19 de octubre 2016

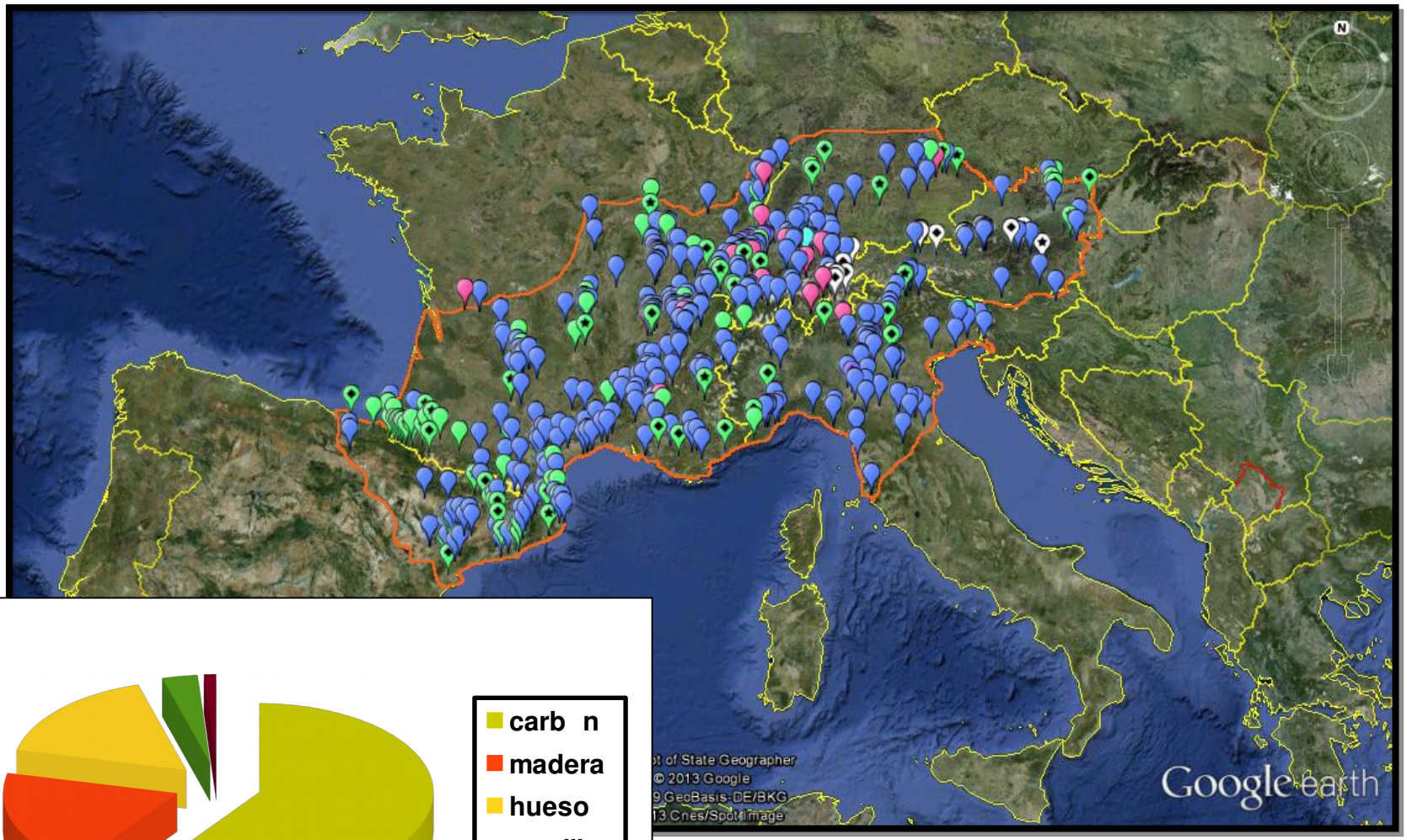
El congreso Cronometrías Para la Historia de la Península Ibérica surge de la necesidad de sistematizar e integrar de manera exhaustiva miles de dataciones cronométricas existentes y sus contextos asociados. Esta reunión científica pretende ofrecer un espacio de debate sobre temas teóricos, metodológicos, sustantivos y prácticos acerca de la datación de eventos históricos. Aunque el uso del método C14 es más frecuente para los contextos posteriores a 50.000 BP, aquí queremos tratar todos los métodos físico-químicos que están hoy en día en práctica, o en fase de uso experimental. Aquí pensamos principalmente en uranium-torium, termoluminiscencia, geomagnetismo, dendrocronología.

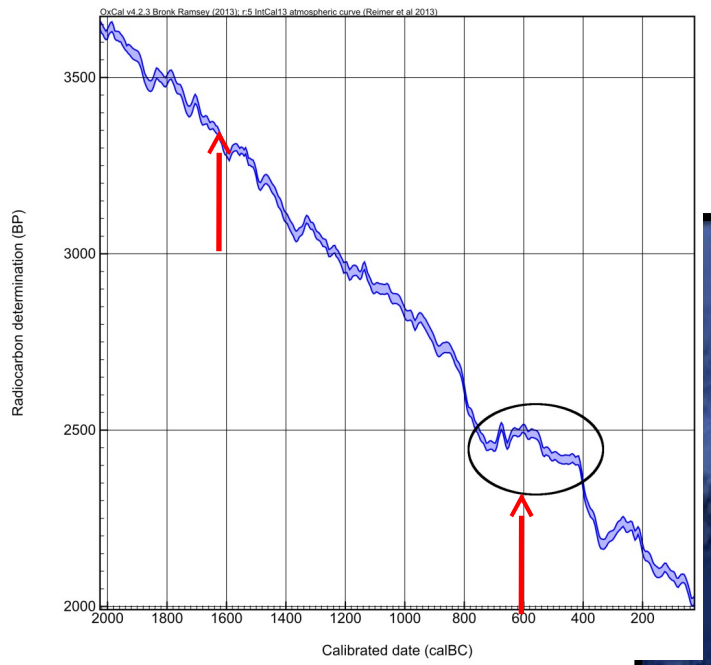
El C14 y otros métodos cronométricos han demostrado su utilidad en la investigación arqueológica del pasado de la península Ibérica, así como en los archipélagos de la Baleares, Canarias y Madeira. Desde 1950 se han acumulado miles de dataciones de contextos arqueológicos. Sin embargo, el acceso a las mismas es difícil, debido al formato de su presentación, a la inconsistencia en la presentación de los contextos asociados y a la dispersión extrema de las publicaciones. En 1978 (Almagro-Gorbea y Fernández-Miranda) y en 1996 (Lull, Castro y Risch) se presentaron esfuerzos sintetizadores de enorme valor para su tiempo. Desde entonces se han publicado algunos trabajos sintéticos sobre periodos concretos, pero falta una visión general crítica de la potencialidad de la cronometría para datar la historia de las sociedades que vivieron en la península Ibérica y archipélagos.

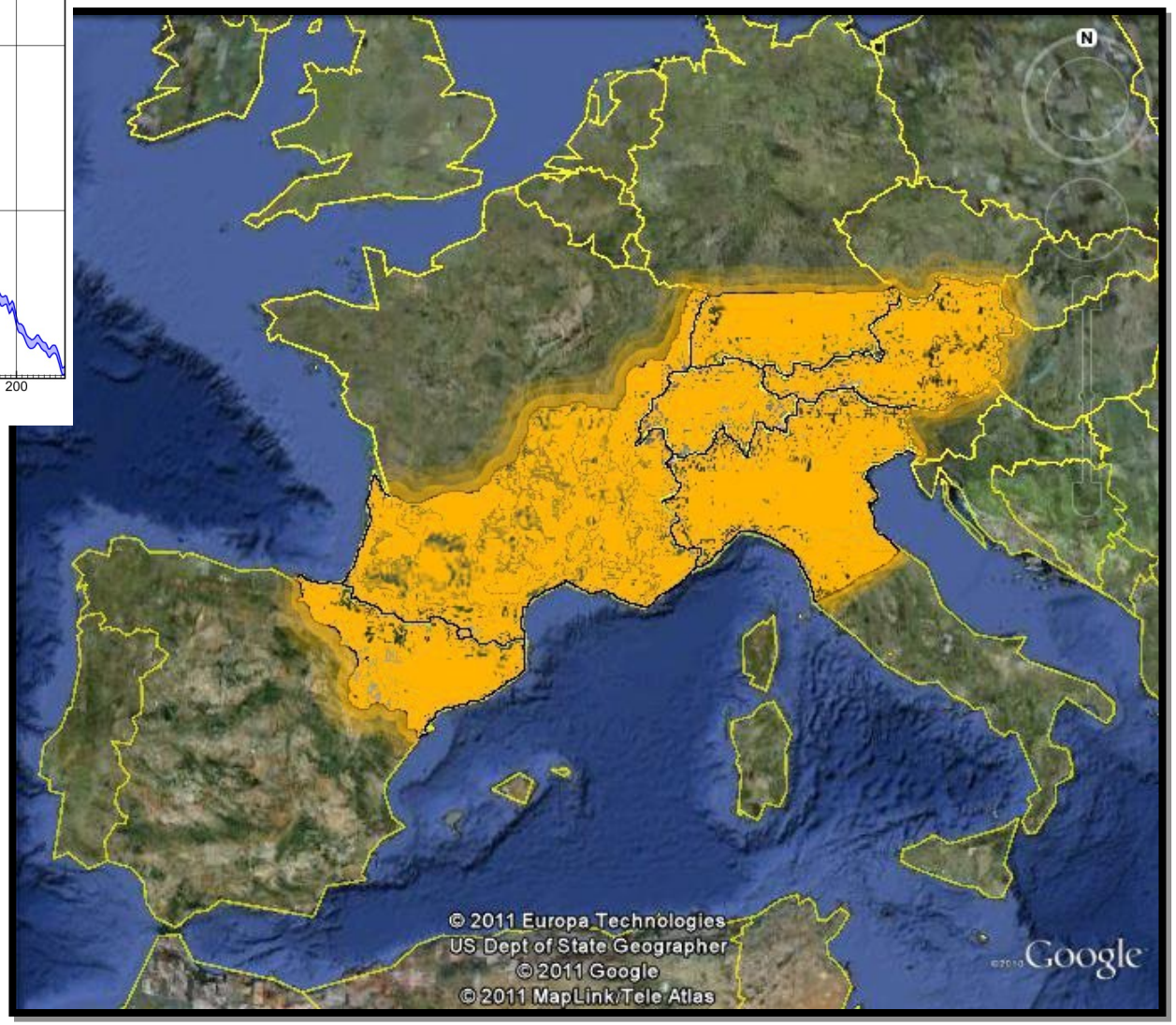
S'està connectant a platform.twitter.com...

ES 10:05 24/03/2016

EUBAR: 1567 dataciones procedentes de 573 sitios arqueológicos, un yacimiento fechado por el ^{14}C cada 916 Km^2




OxCal v4.2.3 Bronk Ramsey (2013); r:5 IntCal13 atmospheric curve (Reimer et al 2013)
Radiocarbon determination (BP)
3500
3000
2500
2000
2000
1800
1600
1400
1200
1000
800
600
400
200
Calibrated date (calBC)


N
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Entry 15

Site

Can Piteu-Can Roqueta

Municipality Sabadell
Province/District Barcelona
Comarca Vallès Occidental
Region 5
Autonomous community Catalunya
Departament -
Canton -
Geographic region Depresión Prelitoral (central)
Country España
Coord. X 428122
Coord. Y 4598692
Stratigraphy -

Chronology

Laboratory KIA-24835 AMS

Year dating 2004
Year BP (literature) 2755
Standard error 30

Year BC recalibrated

Inferior boundary 95 978
Superior boundary 95 827
Inferior boundary 68 924
Superior boundary 68 842

Spanish chronology Bronce Final B
French chronology
Italian chronology
German chronology

Function

Functional context Funerario
Type of site Necrópolis de incineración

Material

Analysed material Hueso humano
Provenance Urna 294-34B

Context

Context reliability ☒ si ☐ no

Settlement area

Traces of fortification no
Elaboration of copper no
Elaboration of bronze no
Elaboration of iron no
Finding of copper no
Finding of bronze si
Finding of iron no
Predominant domestic animal -
Evidence of agriculture no det.

Necropolis

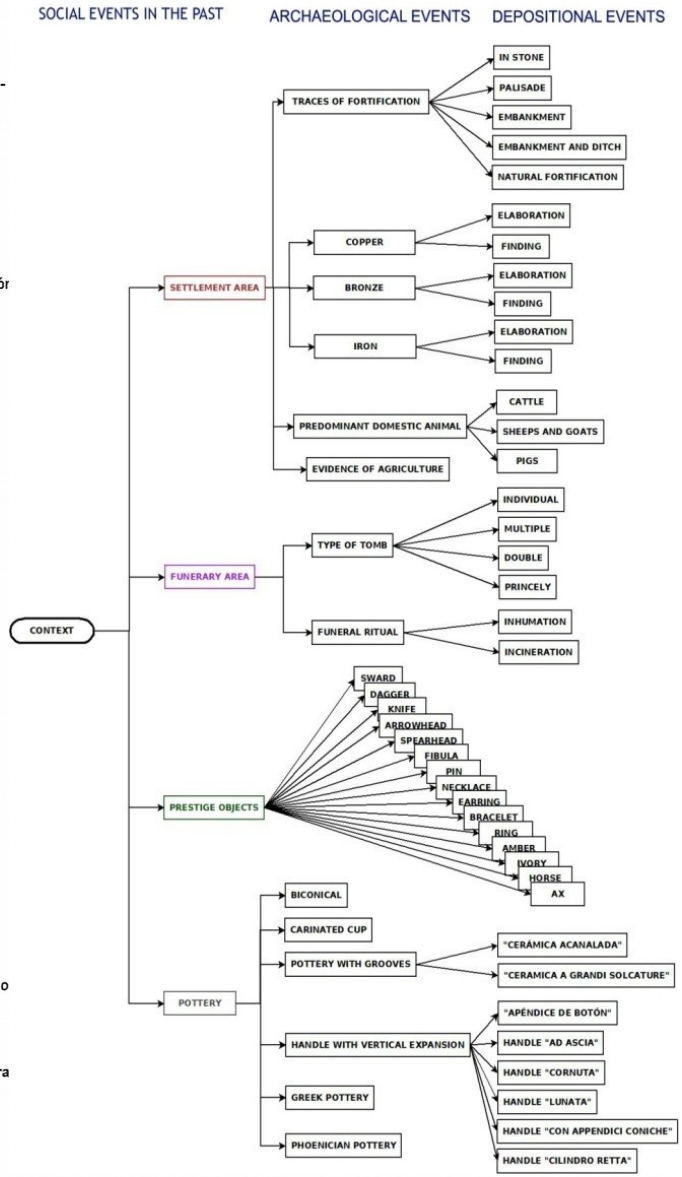
Type of tomb Individual
Funeral ritual Incineración

Prestige objects

Sward no
Dagger no
Knife si
Arrowhead no
Spearhead no
Fibula no
Pin no
Necklace no
Earring no
Bracelet no
Ring no
Amber no
Ivory no
Ax no
Horse no

Pottery

Biconical no
Carinated cup no
Pottery with grooves si
Handel with vertical expansion no
Decoration with "sogueado" no
Decoration with meanders no
Decoration with "dientes de sierra
Zig zag decoration si
Greek pottery no
Phoenician pottery no

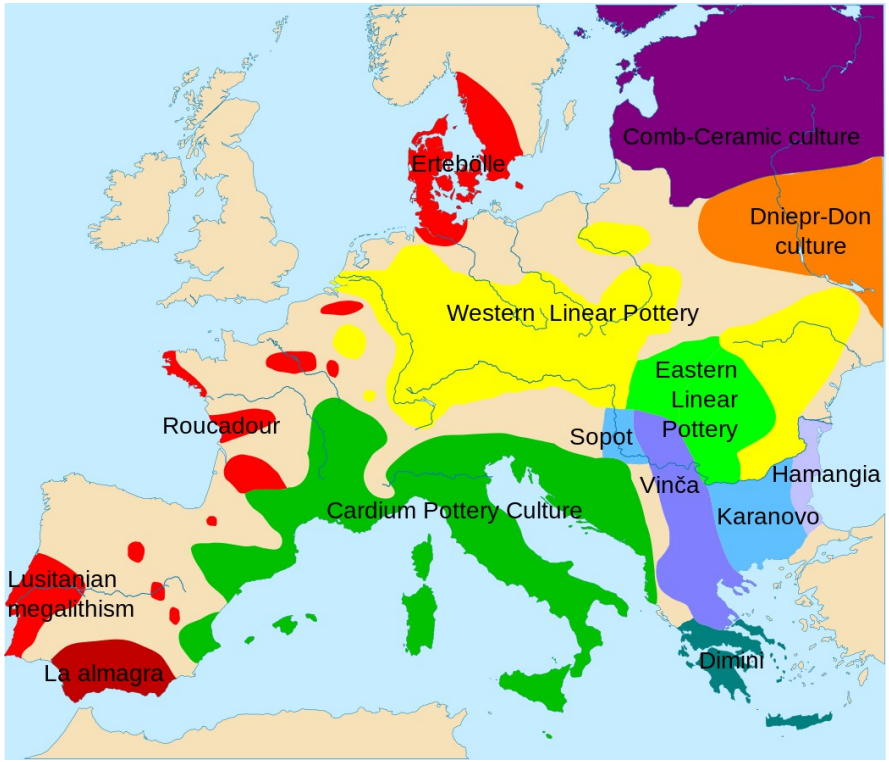


Bibliography

LÓPEZ CACHERO F. J. 2005, pp. 460-462.
CARLÚS X., LÓPEZ CACHERO F. J., OLIVA M., PALOMO A., RODRIGUEZ A., TERRATS N., LARA C., VILLENA N. 2007, pp. 83-89, 137-182, 191-195.
CARLÚS X., LÓPEZ CACHERO F. J., TERRATS N., OLIVA M., PALOMO A., RODRIGUEZ A. 2008, pp. 119, 135 (fig. 19A), 140-141.

Notes

NEOLITICO FINAL. Sepulcros de Fosa-Chassey-Lagozza-Cortaillod



Spatial analysis

The Nature of the Archaeological problem

Where activity X occurred?

Archaeological observables are not the activity, but something generated indirectly during the occurrence of the activity

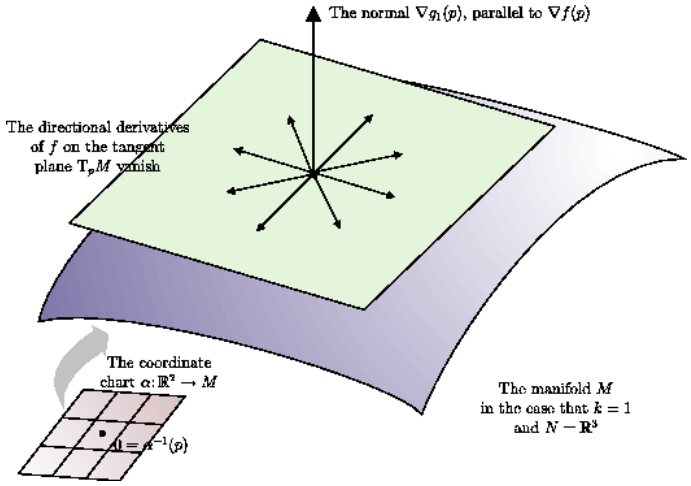
The Nature of the Archaeological problem

Activity *X* took place there!

Intuitively: where count data are the more abundant

An Intuitive Model for Spatial Intra-site Problems

Where activity X occurred?



e probability an activity took place somewhere is determined by the abundance and den
Of the material consequences of that activity

An Intuitive Model for Spatial Intra-site Problems

NELSON's Law

Discard Equation (Schiffer)

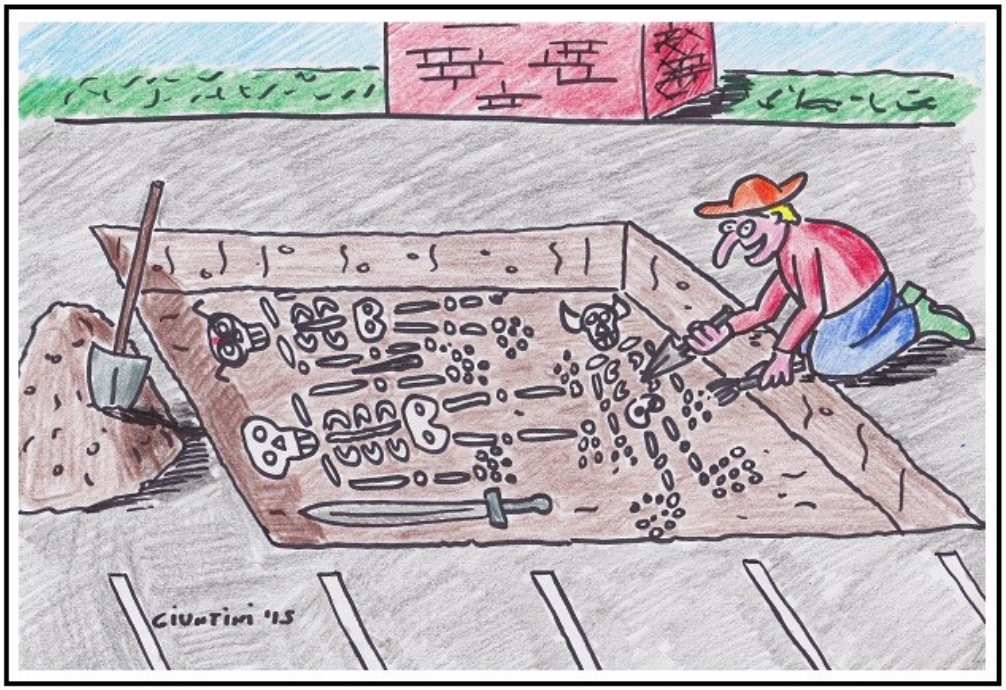
$$T_D = S^* t/L$$

CLARKE's effect

S= the number of artifacts normally in use
t= total period of occupation,
L = the use-life of the artifact,

The quantity of observed archaeological remains is a function of temporal duration of occupation, the size of the involved human group, and the nature of the activity itself

Spatial Prediction at the intra-site observation scale



Is the probability of an action occurred at a particular place the same as the detection probability of an individual artefact linked to a particular activity at the same place?

Spatial Prediction at the intra-site observation scale

Since the original work by Krakker et al. 1983
(see also Kintigh 1988, Shott 1989,....)

the likelihood of an archaeological find within a given survey area is the product of three probabilities:

A) the probability that an archaeologist unearths what is buried (which is a function of the exvacation area size and the archaeological intervention layout);

B) the probability that an artifact contained in the sampled area would be detected by the archaeologist (which among other things depends on whether or not the depositional unit contents are screened, the size and composition of the artifact, and the nature of sediment);

C) the probability that the

Spatial Prediction at the intra-site observation scale

the detection probability of an individual artefact can be determined using the following equation (Verhagen et al., 2013)

$$D = 1 - e^{-AdW}$$

where

D = detection probability;
e = the base of natural logarithms (2.711828);
A = the area of the sampling unit;
d = the density of artefacts per area unit; and
W = the observation probability, i.e. the probability that an artefact will be recognized as such when it is recovered.

Spatial Prediction at the intra-site observation scale

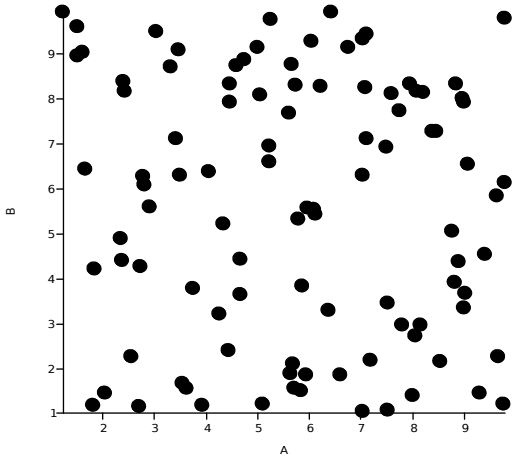
We can modify Verhagen's model of detection probability of artifacts adding Schiffer discard equation

$$P = 1 - e^{-AdTD}$$

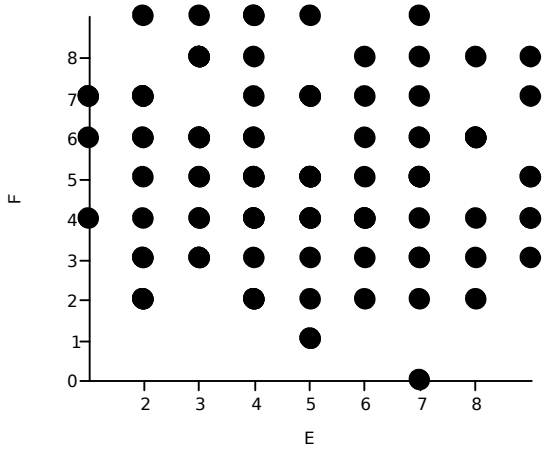
where

D = Probability the action too occurred at this place
e = the base of natural logarithms (2.711828);
A = the area of the sampling unit;
d = the density of artefacts per area unit; and
TD = Number of particular refuse material generated by that action at that particular place during the occupation span

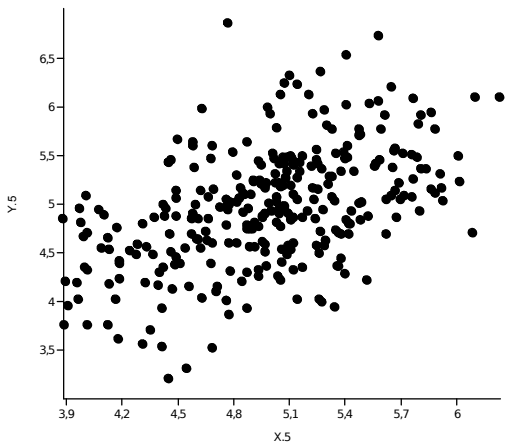
PROCESOS ESPACIALES



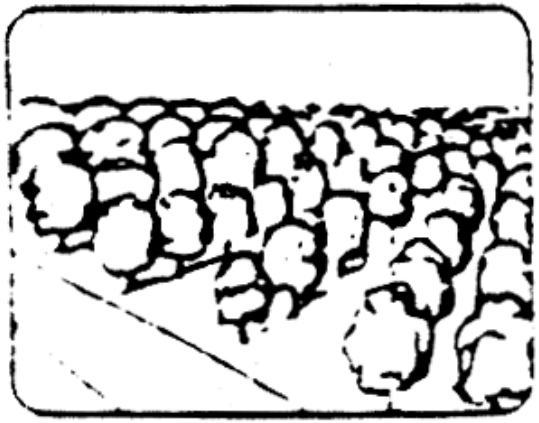
ALEATORIO

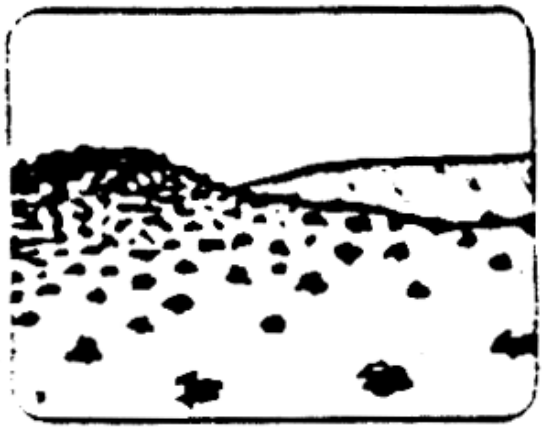


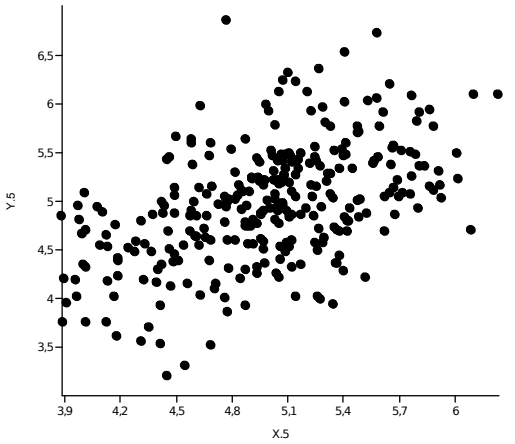
UNIFORME

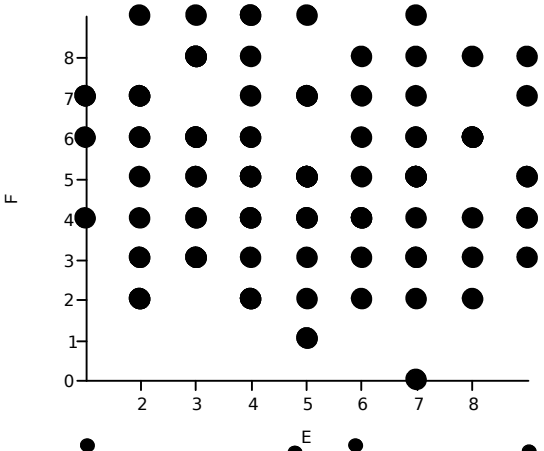


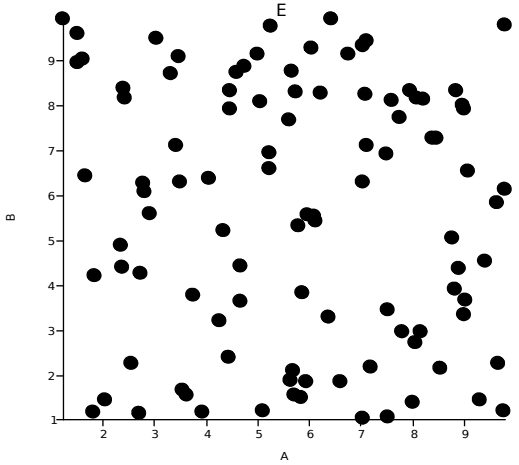
CONCENTRADO



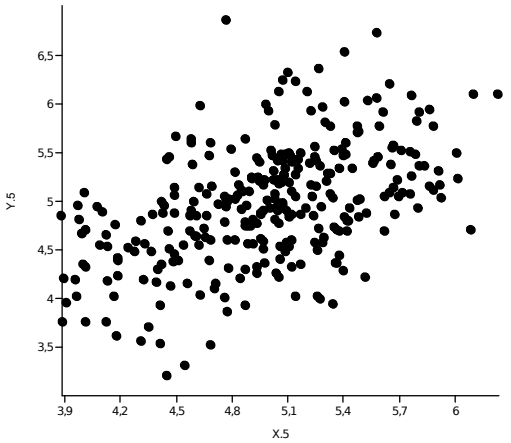




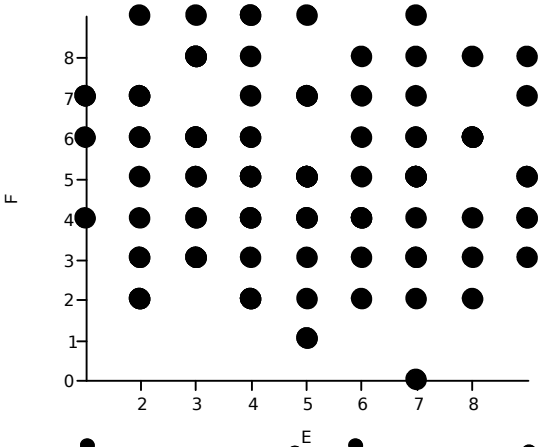




- **Is observed clustering due mainly to natural background variation in the population from which events arise?**
- **Over what spatial scale does any clustering occur?**
- **Are *clusters* merely a result of some obvious a priori heterogeneity in the region studied?**
- **Are they associated with proximity to other specific features of interest, such the location of some other social action or possible point sources of important resources?**
- **Are events that aggregate in space also clustered in time?**



Concentrado



Uniforme

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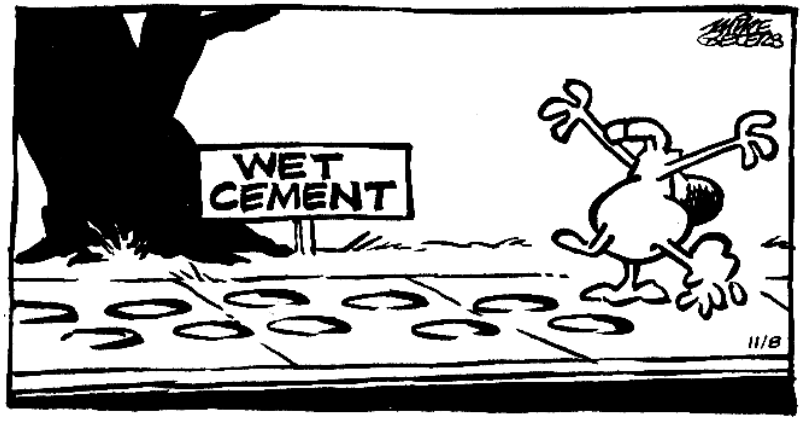

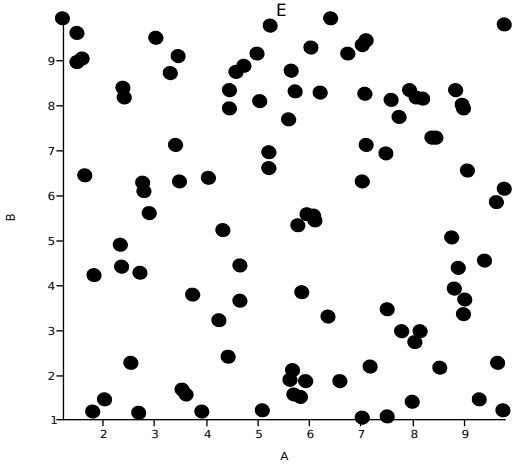

Aleatorio

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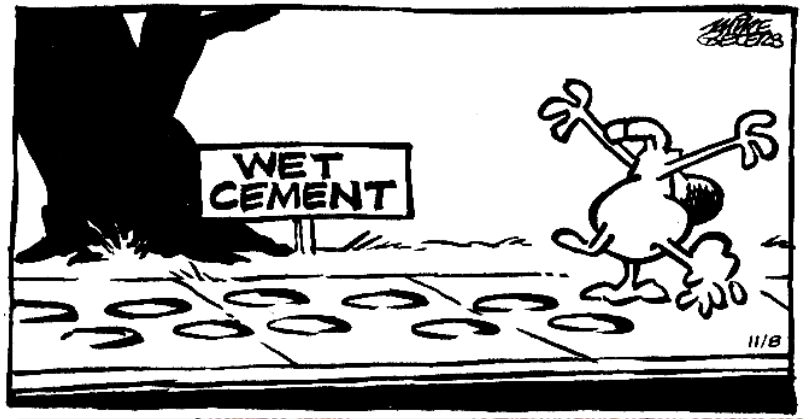
Conducta espacialmente agregada



Conducta espacialmente uniforme

"Sorry about the mess. I invited a few of my dog friends over to watch the game and things got a little out of hand."

Conducta espacialmente aleatoria

Aggregated Spatial Patterns

uman activity does not take place everywhere, but if happened at some specific places b
ne local conditions of places and the social and mechanical needs of that action.

If the theoretical model is correct, we should expect to find aggregated spatial patterns, instead of the usual spatial random patterns that are used as Null-Hypothesis in geographical or ecological models.

Aggregated Spatial Patterns

THE IMPORTANCE OF ZERO VALUES: EMPTRY PLACES.

Overdispersion: we can say that when points are overdispersed, a point's presence reduces the probability of finding another nearby

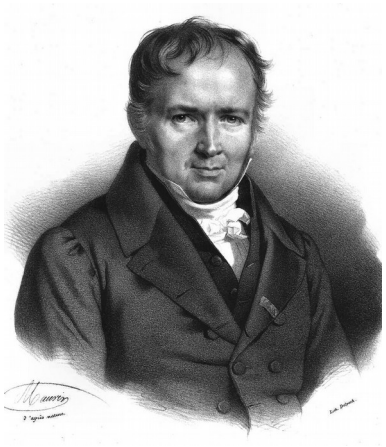
Aggregated Spatial Patterns

THE IMPORTANCE OF ZERO VALUES: EMPTRY PLACES.

Nevertheless, zero inflation may appear in data sets with excess of empty places caused by false-zero observations because of sampling or observer errors in the course of data collection.

What's wrong with Poisson?

It describes the probability that a count unit appears at a sampling (space-time) unit.

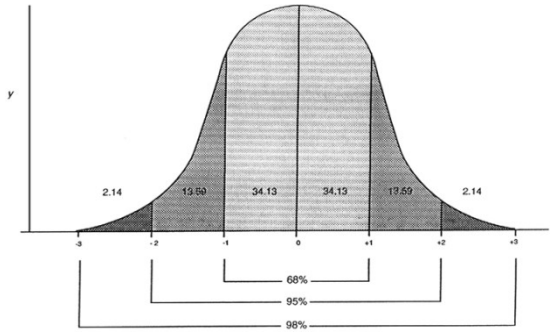


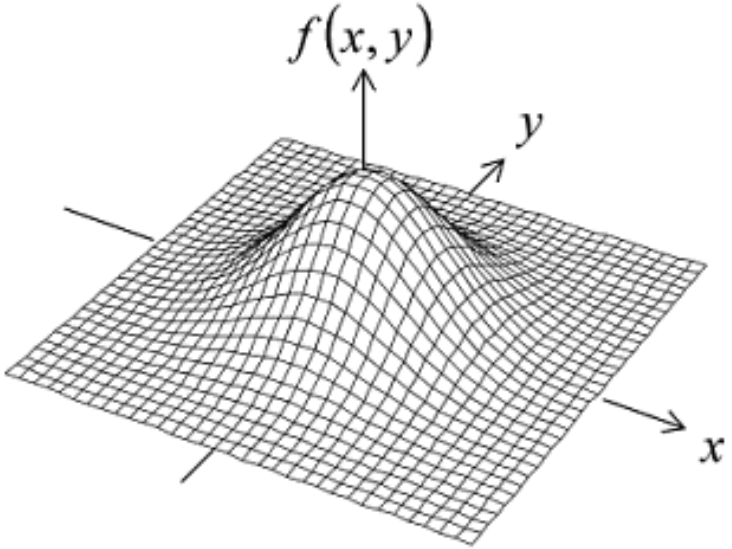
$$f(k;\lambda) = \frac{\lambda^k e^{-\lambda}}{k!}$$

ASSUMPTIONS

1. The probability of a success during a very small interval of time Δt is given by $\alpha \cdot \Delta t$.
2. The probability of more than one success during such a small time interval Δt is negligible.
3. The probability of success in non-overlapping intervals Δt are independent.

The Bivariate Normal Model





The Bivariate Normal Distribution

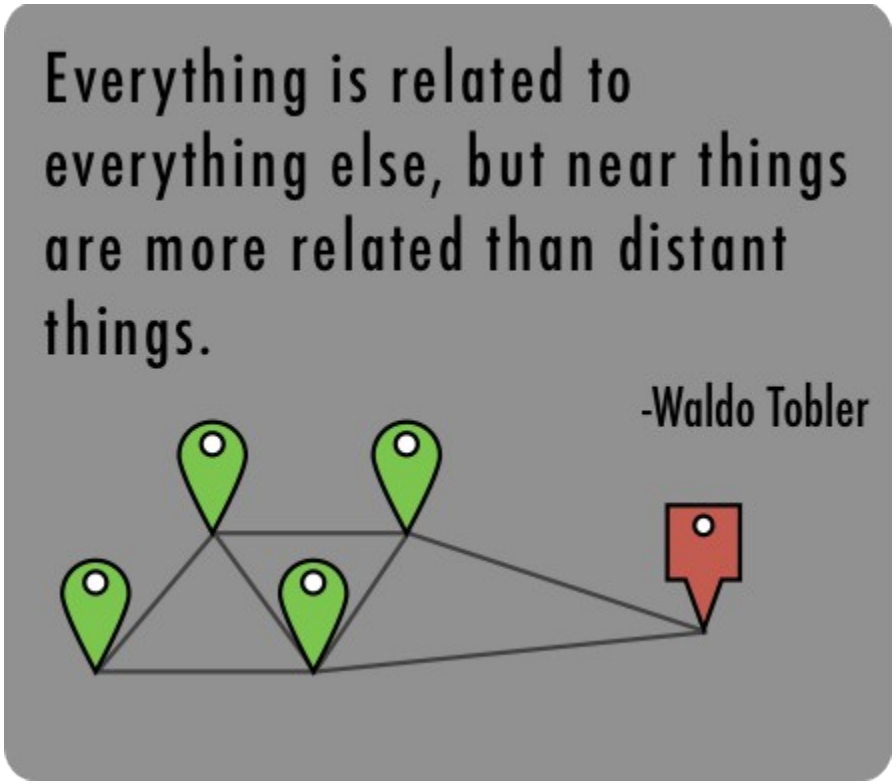
A pair of random variables X and Y have a bivariate normal distribution iff their **joint** probability density is given by

$$f(x,y) = \frac{\mathbf{e}^{\left(\left(-\frac{1}{2(1-\rho^2)}\right)\left(\left(\frac{x-\mu_1}{\sigma_1}\right)^2 - \frac{2\rho(x-\mu_1)(y-\mu_2)}{\sigma_1\sigma_2} + \left(\frac{y-\mu_2}{\sigma_2}\right)^2\right)\right)}}{2\pi\sigma_1\sigma_2\sqrt{1-\rho^2}}$$

for $-\infty < x < \infty$ and $-\infty < y < \infty$, where $\sigma_1 > 0$, $\sigma_2 > 0$, and $-1 < \rho < 1$.

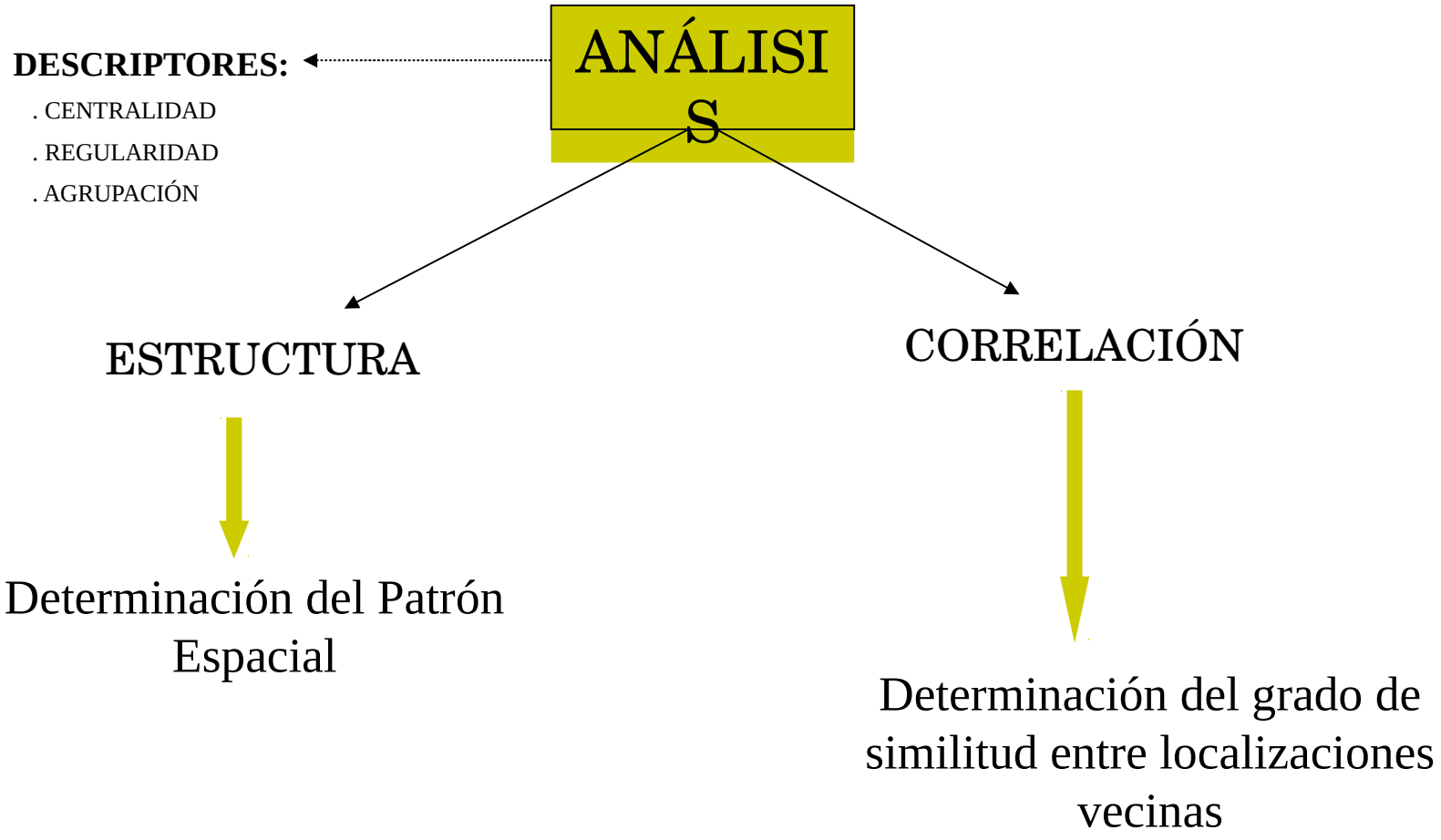
Spatial Dependence and Tobler's Law

Human dispersal of material elements fast never is ran



Metodología de análisis de la variabilidad espacial.

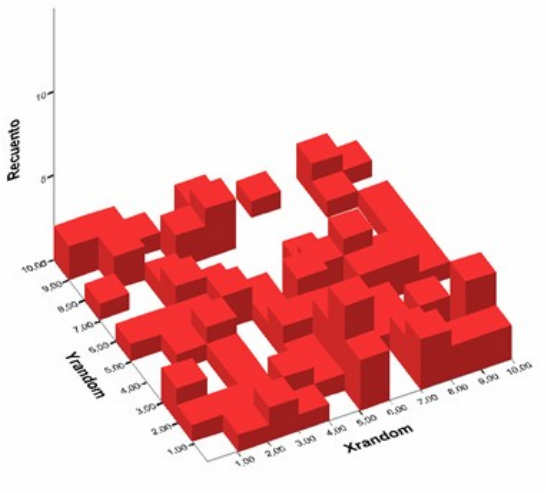
¿**Cómo** se estudia la *variabilidad espacial* observada?

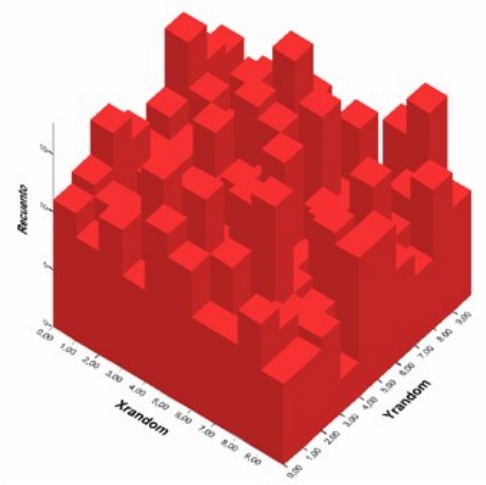


First order Spatial Analysis

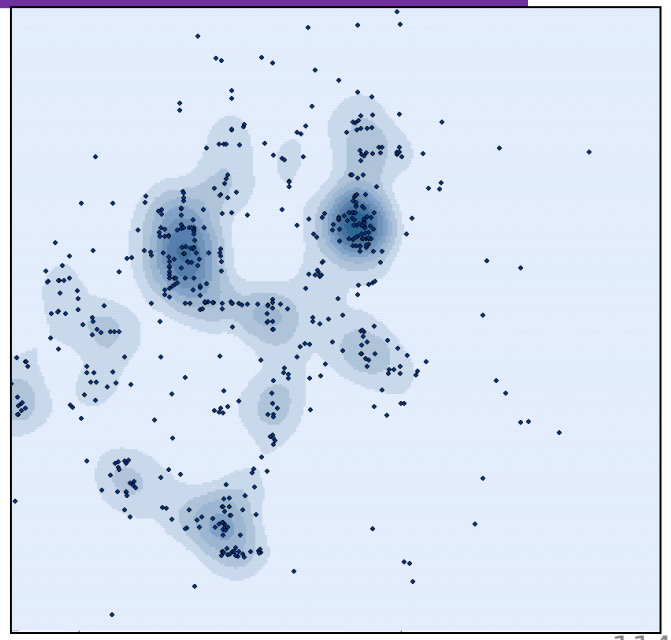
Variation in spatial pattern indicative of the INTENSITY of a process at particular location

3D histogram





Kernel 2D density



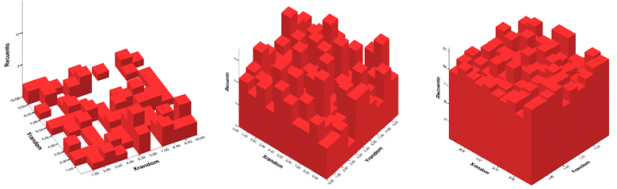
4. Análisis espacial de poblaciones teóricas.

POBLACIONES TEÓRICAS

i. PROCESO ALEATORIO (n=100; n=1000): La ausencia de la relación

Incremento en **n** provoca:

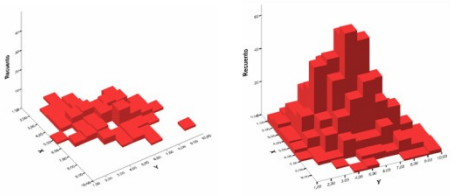
- Mayor irregularidad en la TASA DE CAMBIO = Retículas vecinas sin relación.
- Una tendencia a la homogeneidad espacial "difuminando" la aleatoriedad



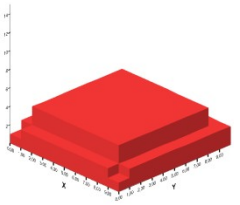
ii. PROCESO ESPACIALMENTE NORMALIZADO (n=100; n=1000): La relación positiva.

Incremento en **n** provoca:

- Retículas vecinas con relación.
- Refuerza el carácter binormal.



iii. PROCESO ESPACIALMENTE uniforme (n=325; n=179): La relac
Negativa. (distribución Poisson).



Análisis espacial de poblaciones teóricas.

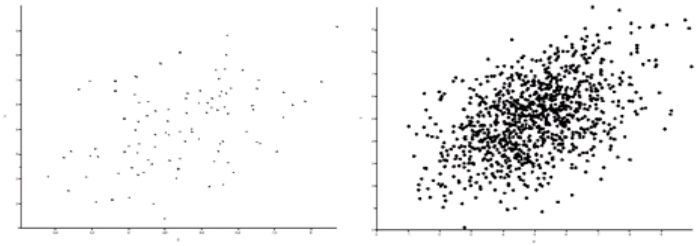
IMPLICACIONES:

REGISTRO DE LA VARIABILIDAD ESPACIAL: ¿Coordenados o Frecuencia?

Problema: El formato de datos condiciona las pruebas a realizar.

Solución: Congruencia en las herramientas analíticas.

CONSECUENCIA: La interpretación (modelo) necesita de datos GEOESTADÍSTICOS (frecuencia espacial), aunque lo ideal es partir desde COORDENADOS.



10	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	1	0	0
8	0	0	0	0	0	1	1	0	0	0
7	0	0	0	0	4	2	3	0	0	0
6	0	0	1	3	3	8	4	2	1	0
5	0	0	0	1	5	5	4	2	0	0
4	0	0	1	3	7	6	4	1	0	0
3	0	1	2	4	6	4	2	0	0	0
2	0	0	1	3	0	1	1	0	0	0
1	0	0	0	0	2	0	0	0	0	0
	1	2	3	4	5	6	7	8	9	10

10	0	0	0	0	0	1	2	0	1	0
9	0	0	0	1	2	8	4	4	2	0
8	0	0	3	7	18	23	5	7	1	0
7	0	5	11	29	48	29	17	0	0	0
6	6	5	35	59	72	36	11	6	1	0
5	5	16	36	59	56	28	10	1	2	0
4	6	24	50	51	32	17	8	0	0	0
3	5	17	21	31	12	5	3	0	0	0
2	9	10	8	10	5	1	0	0	0	0
1	0	2	0	0	0	0	0	0	0	0
	1	2	3	4	5	6	7	8	9	10

Visualización Patrón Espacial

KERNEL DENSITY ESTIMATION :

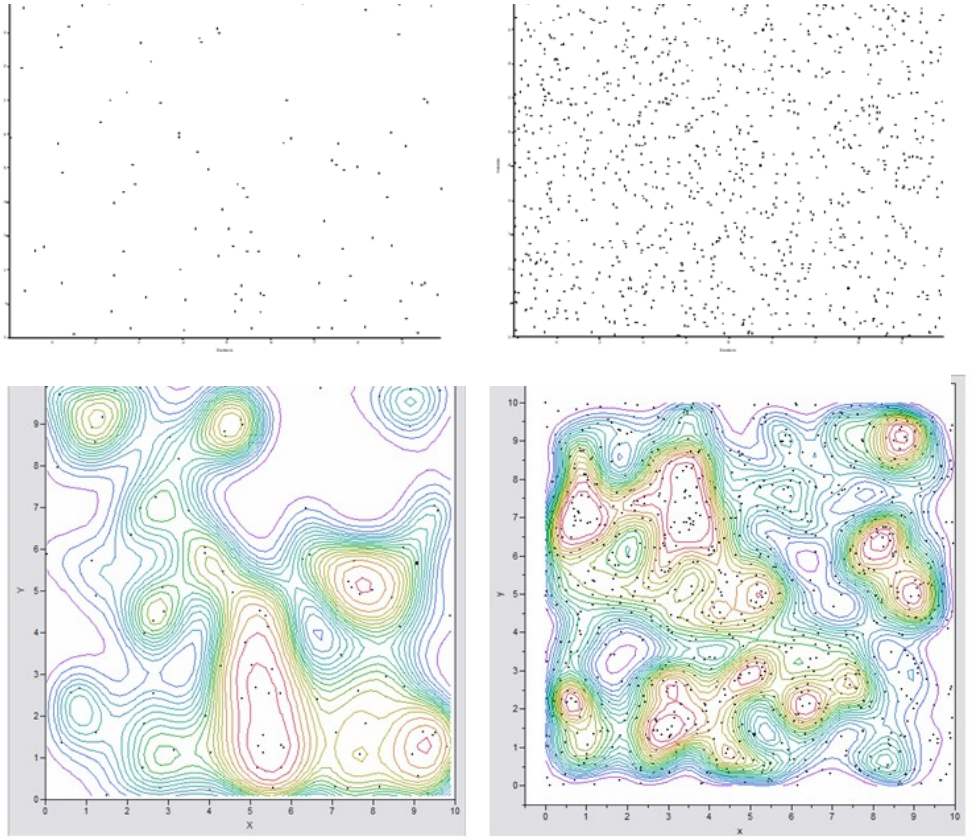


Figura 35: Densidad Kernel en 2D; n=100 a la izquierda, n=1000 a la derecha.

Visualización Patrón Espacial

KERNEL DENSITY ESTIMATION

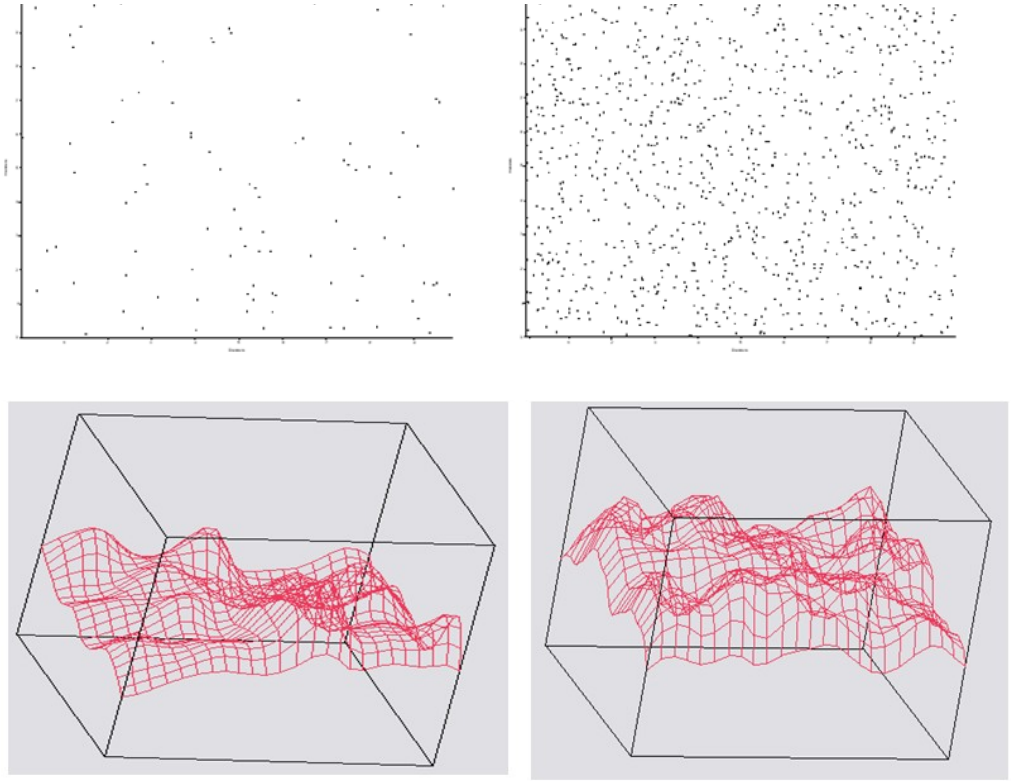
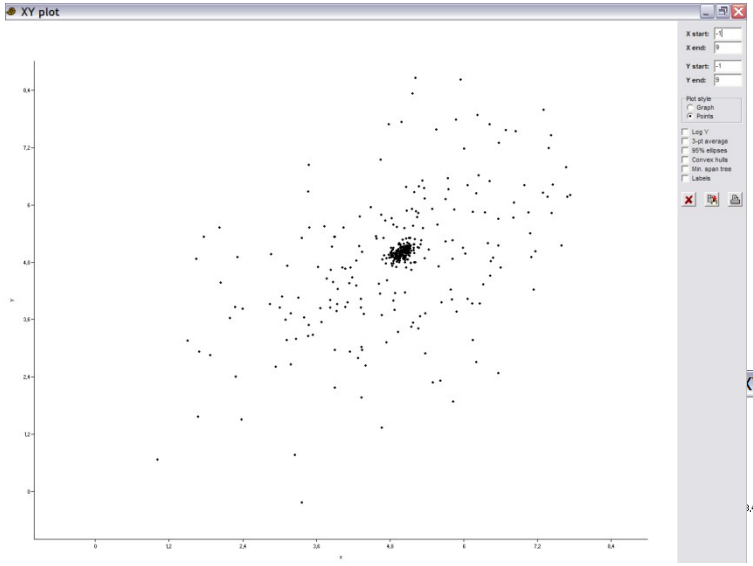
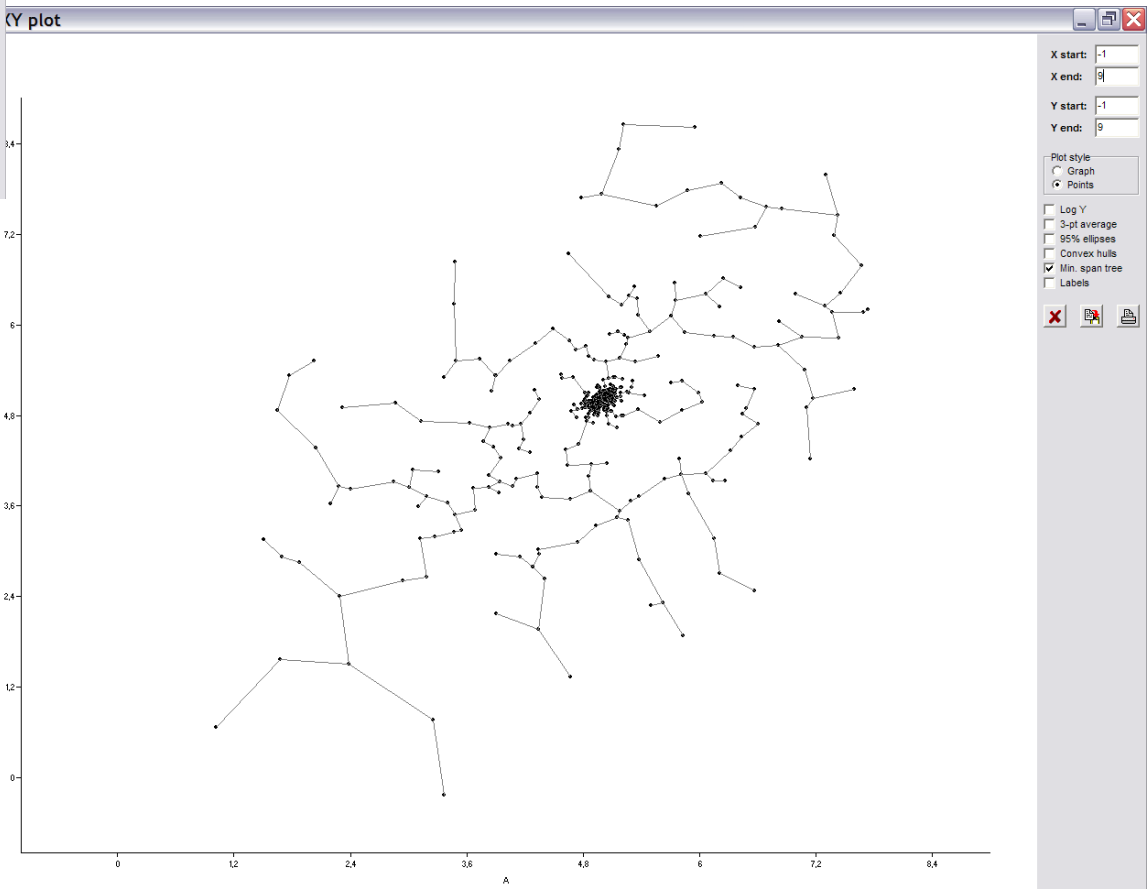


Figura 35: Densidad Kernel en 2D; n=100 a la izquierda, n=1000 a la derecha.

Describing spatial variability: minimum spanning tree

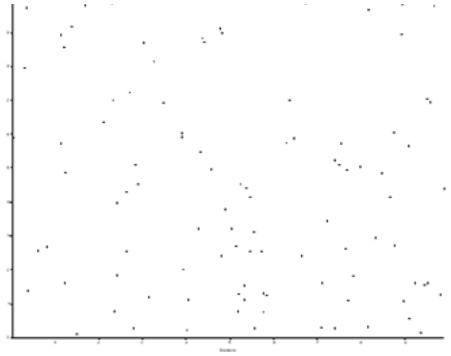


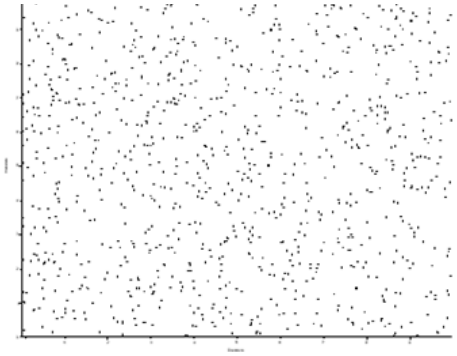
PAST:

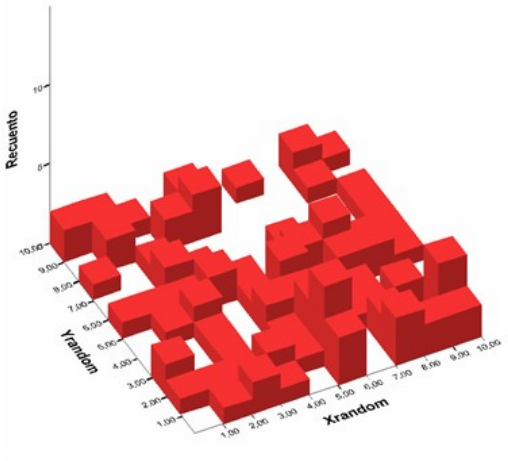


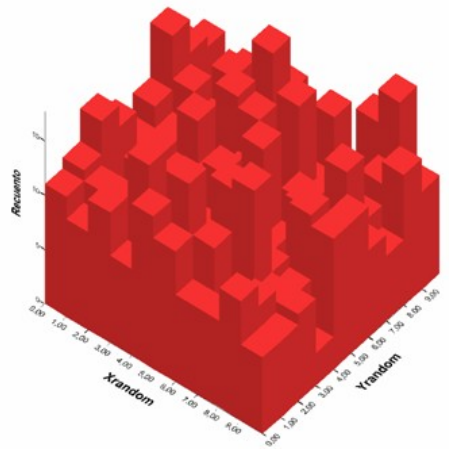
Visualización Patrón Espacial

Diagrama de barras 3D : x / y / frecuencia:spss



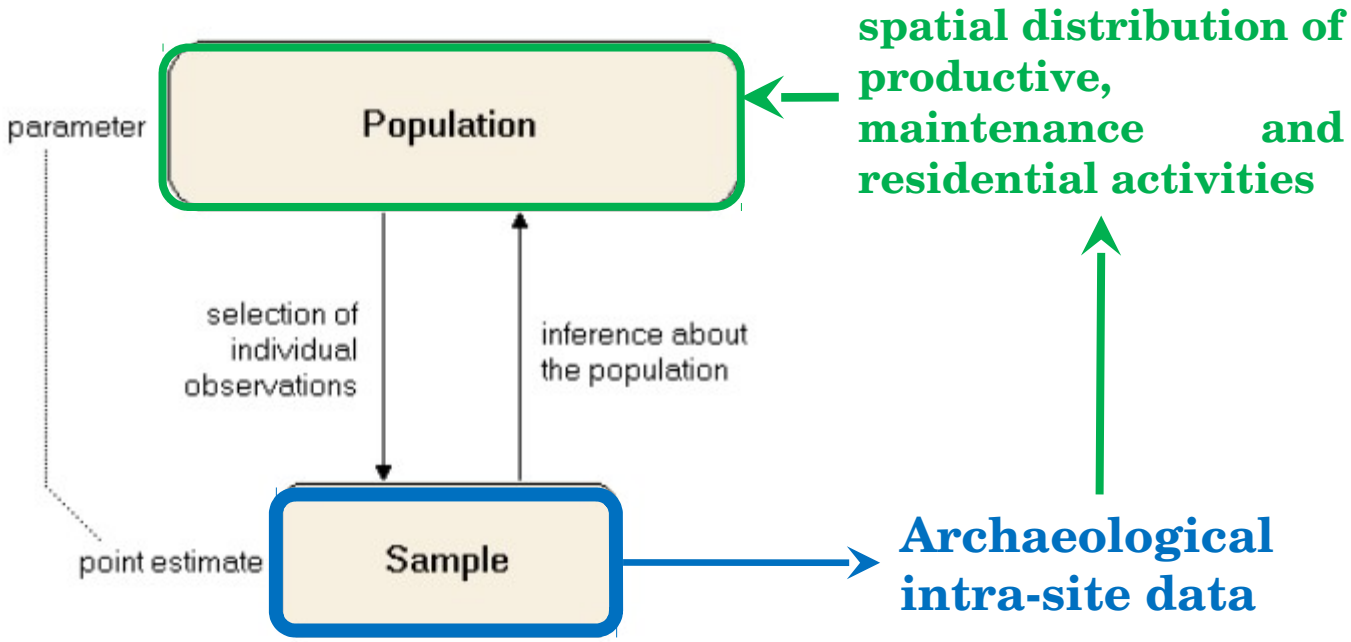






Spatial Prediction at the intra-site scale

Where *social action happened?*



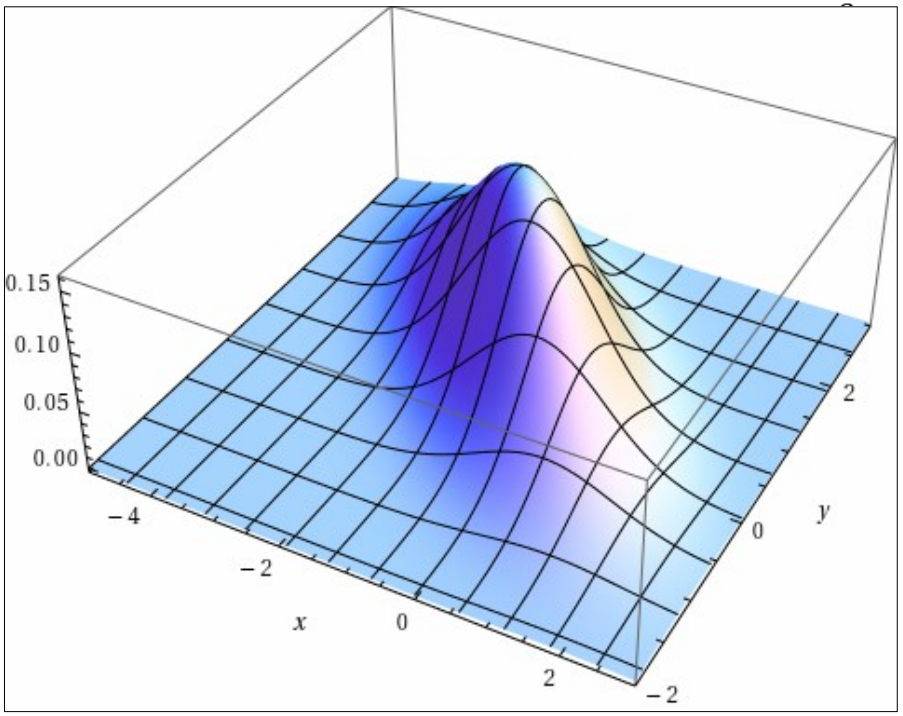
Where *archaeological observables occur?*

FITTING BIVARIATE NORMAL

Test of Mardia

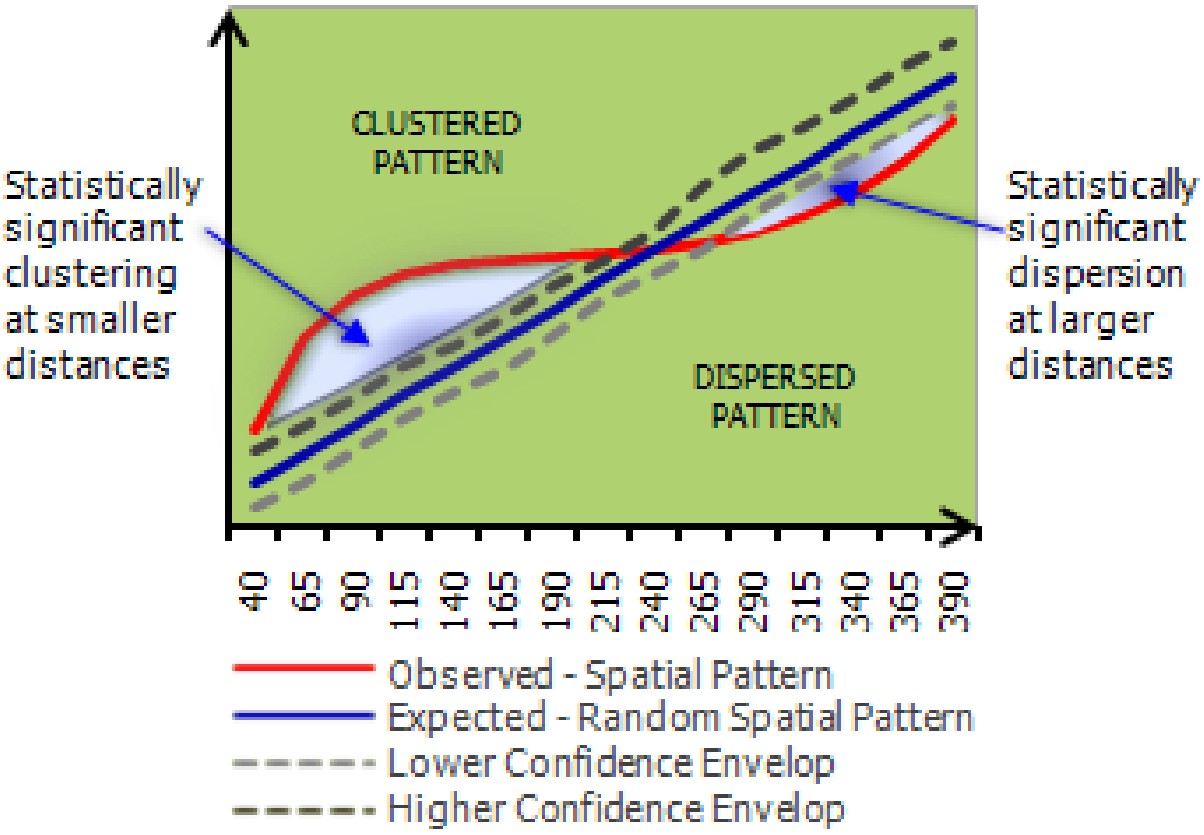
$$b_{2,d} = \frac{1}{n}\sum_{i=1}^{n}\left[(X_i - \mu)' S^{-1} (X_i - \mu)\right]$$

skeweness and kurtosis multivariate test

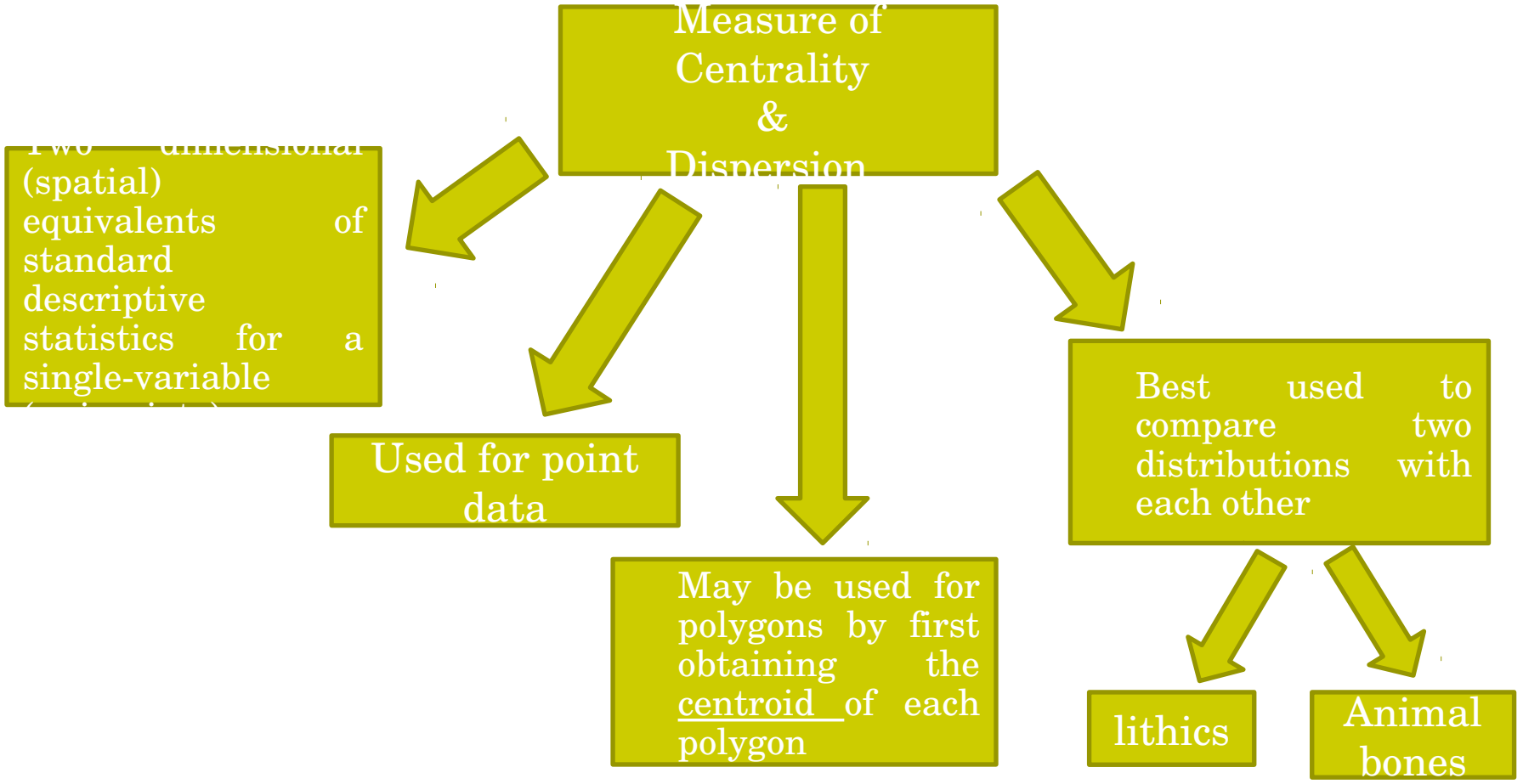


Normality Test			
Equation	Test Statistic	Value	Prob
System	Mardia Skewness	14.32	0.1588
	Mardia Kurtosis	1.56	0.1185

MEASURING THE DEGREE OF AGGREGATION



Centrographic Statistics



Centrographic Statistics

Measure of Centrality:

- Mean Center
- Centroid
- Weighted Mean Center
- Center of Minimum Distance

Mean Center: Identifies the mean center-point (X and Y) of a group of points. Minimizes sum of squared distances between itself and all points

$$\bar{X} = \sum_{i=1}^{N} \frac{X_i}{N}$$

$$\bar{Y} = \sum_{i=1}^{N} \frac{Y_i}{N}$$

Weighted Mean Center: produced by weighting each X and Y coordinate by another variable (W_i)

Centroids derived from polygons can be weighted by any characteristic of the polygon (as each archaeological structure)

$$\bar{X} = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i} \qquad \bar{Y} = \frac{\sum_{i=1}^{n} w_i y_i}{\sum_{i=1}^{n} w_i}$$

Center of minimum distance or Median Center: Identifies point at which distance to all other points is minimum. It minimizes sum of distances between itself and all other points ($_i$)

$$\min \sum d_{iMD}$$

Centroid: The center of gravity or balancing point of a polygon

The center of gravity or balancing point of a polygon

Centrographic Statistics

Measures of dispersion

Standard Distance Deviation

Represents the standard deviation of the
distance of each point from the mean center

Is the two dimensional equivalent of standard deviation for a single variable

Provides a single unit measure of the spread or dispersion of a distribution.

Standard Deviational Ellipse

It is a good single measure of the dispersion of the points around the mean center, but it does not capture any *directional bias*

The *standard deviation ellipse* gives dispersion in two dimensions

Centrographic Statistics

Formulae for standard deviation of single variable

$$\sqrt{\frac{\sum_{i=1}^{n}(X_i - \bar{X})^2}{N}}$$

Standard Distance Deviation

Given by

$$\sqrt{\frac{\sum_{i=1}^{n}(X_i - X_c)^2 + \sum_{i=1}^{n}(Y_i - Y_c)^2}{N}}$$

Which by Pythagoras:

$$\sqrt{\frac{\sum_{i=1}^{n} d_{iC}^{\,2}}{N}}$$

Or, with weights

$$\sqrt{\frac{\sum_{i=1}^{n} w_i(X_i - X_c)^2 + \sum_{i=1}^{n} w_i(Y_i - Y_c)^2}{\sum_{i=1}^{n} w_i}}$$

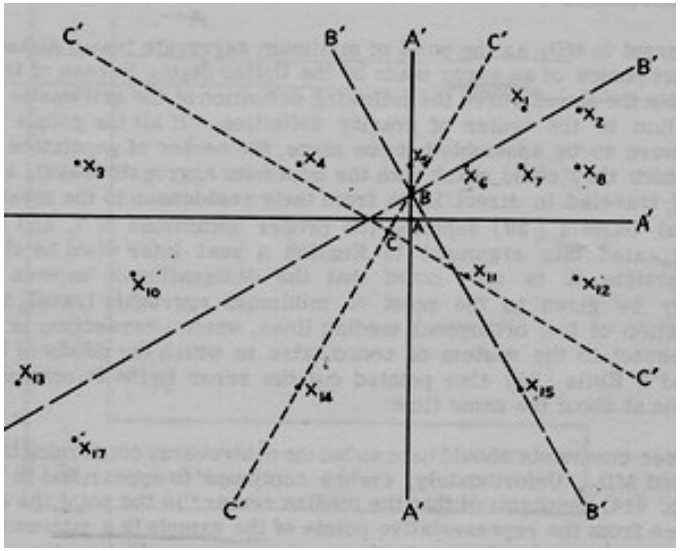
essentially the average distance of points from the center

We can also calculate a weighted standard distance analogous to the weighted mean center

Centrographic Statistics

Center of Minimum Distance or *Median Center*

Also called *point of minimum aggregate travel*



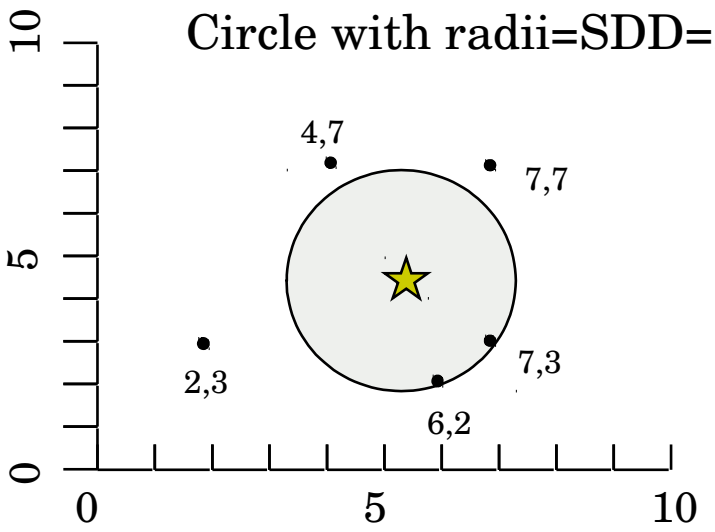
$$X^{t+1} = \frac{\sum_{i=1}^{n} K_i^t X_i}{\sum_{i=1}^{n} K_i^t}$$

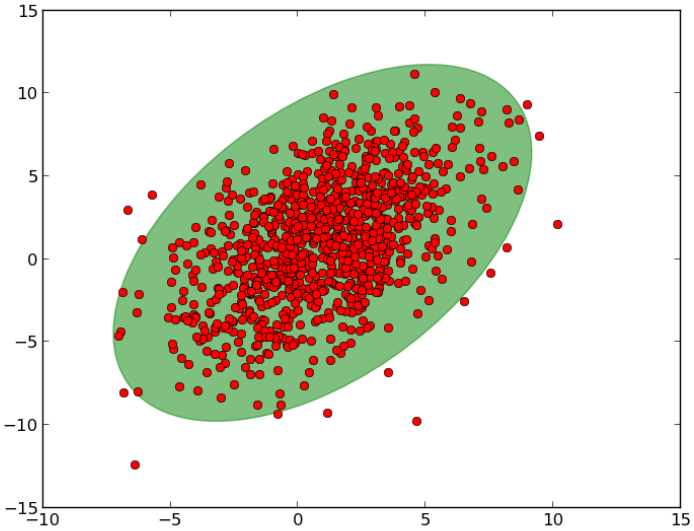
$$Y^{t+1} = \frac{\sum_{i=1}^{n} K_i^t Y_i}{\sum_{i=1}^{n} K_i^t}$$

$$K_i^t = w_i / d_i^t$$

Standard Distance Deviation

$$sdd = \sqrt{\frac{\sum_{i=1}^{n}(X_i - X_c)^2 + \sum_{i=1}^{n}(Y_i - Y_c)^2}{N}}$$





i	X	Y	$(X - Xc)^2$	$(Y - Yc)^2$
1	2	3	10.2	2.0
2	4	7	1.4	6.8
3	7	7	3.2	6.8
4	7	3	3.2	2.0
5	6	2	0.6	5.8
sum	26	22	18.8	23.2
Centroid	5.2	4.4		
			sum of sums	42
			divide N	8.4
			sq rt	2.90

Describing spatial variability: FISRST ORDER ANALYSIS

Mean Center and Standard Distance Deviation

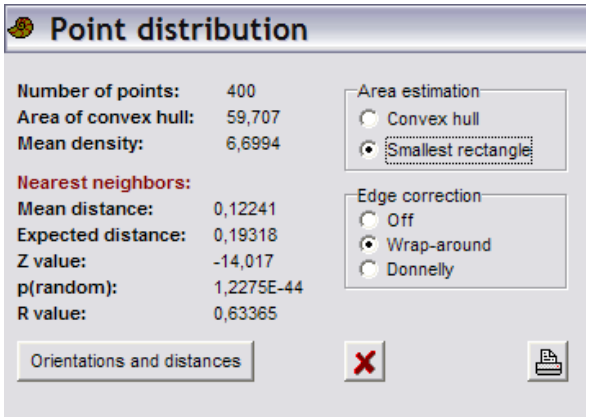
```
Mean Center and Standard Distance Deviation:
--------------------------------------------

    Sample size ...........:  100
    Measurement type ......:  Direct
    Start time ............:  06:08:24 PM, 03/22/2007
    Unit ..................:  Meters

    Variable ..............:             X           Y
    Minimum ...............:      1.010000    3.751000
    Maximum ...............:      6.736000    9.215000
    Mean ..................:      4.116740    6.122780
    Standard Deviation ....:      0.988640    1.117231
    Geometric Mean ........:      3.978663    6.020372
    Harmonic Mean .........:      3.799889    5.916382

    Average Density .......:      3.196230 points per sq. m

    Std Dist Dev ..........:  1.50 m

    Circle Area Defined
    by Std Dist Dev .......:  7.06 sq m
```

```
Standard Deviational Ellipse:
-----------------------------

    Sample size.........................: 100
    Measurement type....................: Direct
    Start time..........................: 06:08:24 PM, 03/22/2007

    Clockwise angle of Y-axis rotation..:  39.392497 degrees
    Ratio of long to short axis.........:  2.0837

    SD along new Y axis:  1.91 m
    SD along new X axis:  0.92 m

    Y axis length:  3.82 m
    X axis length:  1.83 m

    Area of ellipse:  5.51 sq m

    End time............................: 06:08:25 PM, 03/22/2007

Standard Deviational Ellipse (2X):
----------------------------------

    SD along new Y axis:  3.82 m
    SD along new X axis:  1.83 m

    Y axis length:  7.65 m
    X axis length:  3.67 m

    Area of ellipse:  22.04 sq m
```

```
Directional mean and variance:
------------------------------

    Sample size.................: 100
    Start time..................: 06:08:24 PM, 03/22/2007

    Mean angle..................: 53.379000
      (weighted)................: 52.641000
    Circular variance...........: 0.024130
      (weighted)................: 0.017758
    Mean distance...............:  3.98 m, 13.06 ft, 0.00247 mi

    Intersection of mean angle           (X)         (Y)
      and mean distance.........: 4.203754, 6.124706
      (weighted)................: 4.172916, 6.165645

    Triangulated mean...........: 3.870396, 5.876943
      (weighted)................: 4.116504, 6.122580
```

```
Nearest neighbor analysis:
--------------------------

    Sample size........: 100
    Measurement type...: Direct
    Start time.........: 06:12:44 PM, 03/22/2007

    Mean Nearest Neighbor Distance ..:  0.21 m
    Standard Dev of Nearest
    Neighbor Distance .............:  0.18 m
    Minimum Distance ..............:  0.03 m
    Maximum Distance ..............:  6.70 m

    Based on Bounding Rectangle:
    Area ..........................:  31.29 sq m
    Mean Random Distance ..........:  0.28 m
    Mean Dispersed Distance .......:  0.60 m
    Nearest Neighbor Index ........:  0.7542
    Standard Error ................:  0.01 m
    Test Statistic (Z) ............:  -4.7017
    p-value (one tail) ............:  0.0001
    p-value (two tail) ............:  0.0001

             Mean Nearest            Expected Nearest       Nearest
  Order      Neighbor Distance (m)   Neighbor Distance (m)  Neighbor Index
  *****      *********************   *********************  **************
    1                 0.2109                  0.2797            0.75423
```

CRIME III:
www.icpsr.umich.edu/crimestat/



PAST:

Convex Hull:

Sample size .....: 100
Measurement type .....: Direct
Input units ....: Meters
Start time .....: 06:12:44 PM, 03/22/2007

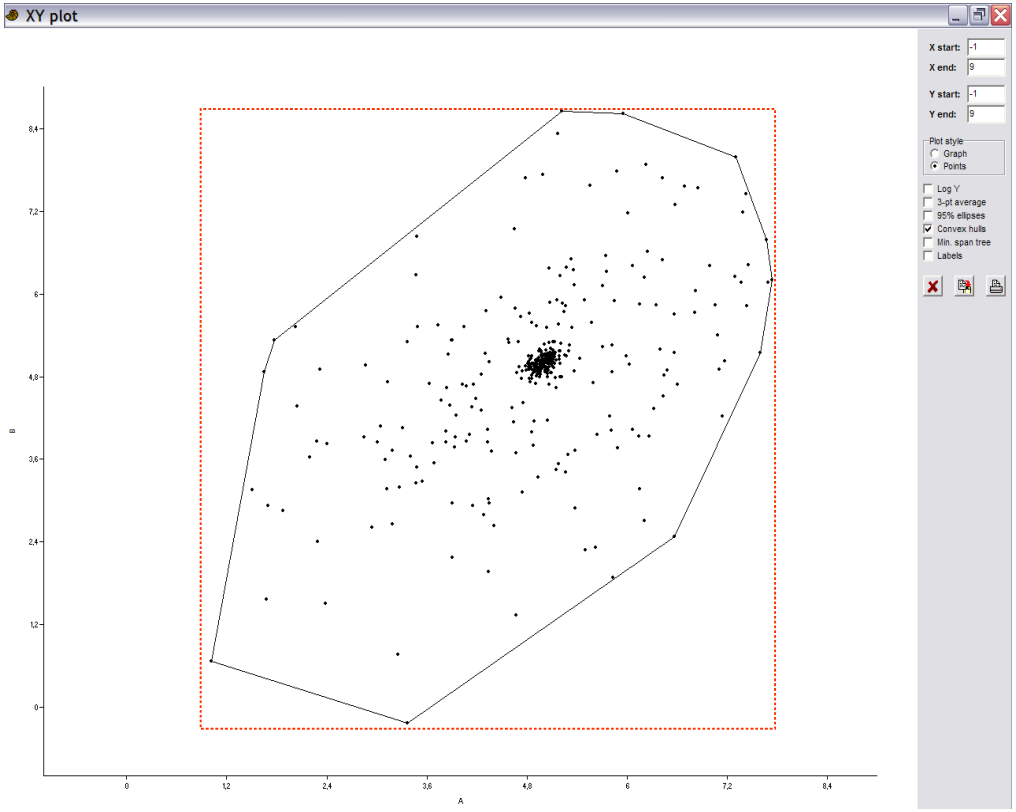
Points in the convex hull: 8

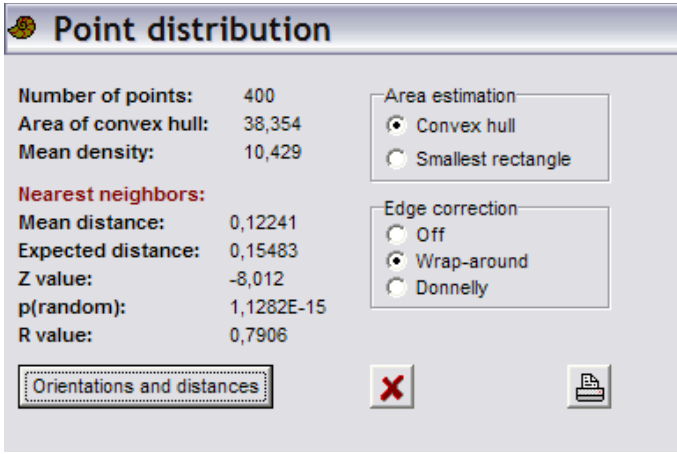
X	Y
4.91700	4.73100
4.40000	3.97300
3.51400	3.75100
1.01000	4.69000
3.36000	7.47000
5.28500	9.21500
6.03000	9.13000
6.73600	7.43100

Describing data variability: convex hull and smallest rectangle

CRIME III:

www.icpsr.umich.edu/crimestat/

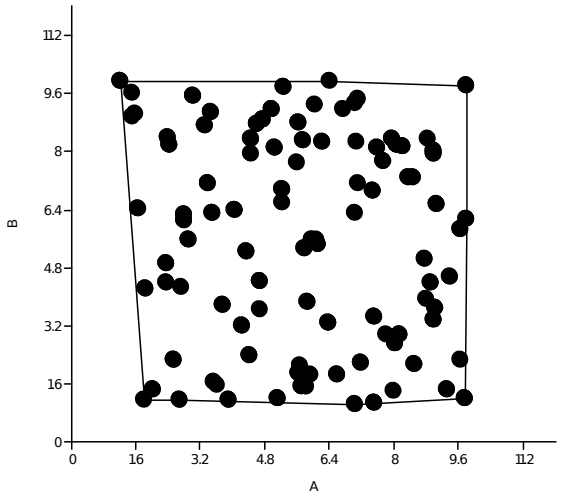




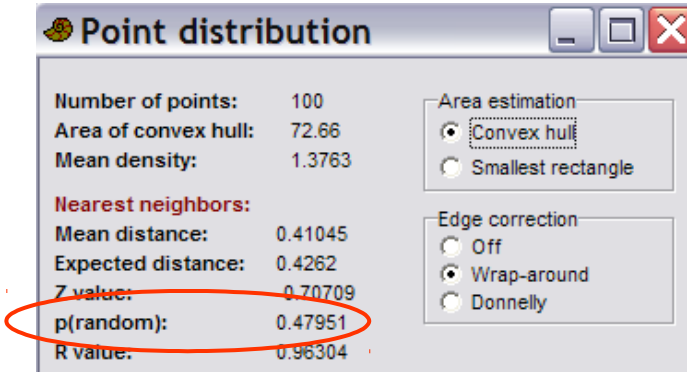
PAST:

Testing spatial randomness

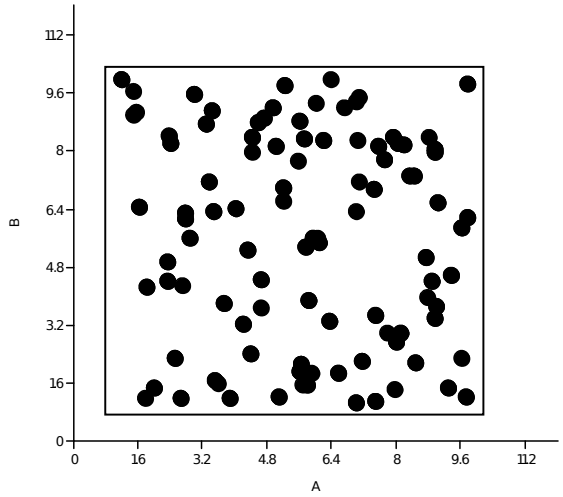
$$R = \frac{2\bar{d}}{\sqrt{A/N}},$$

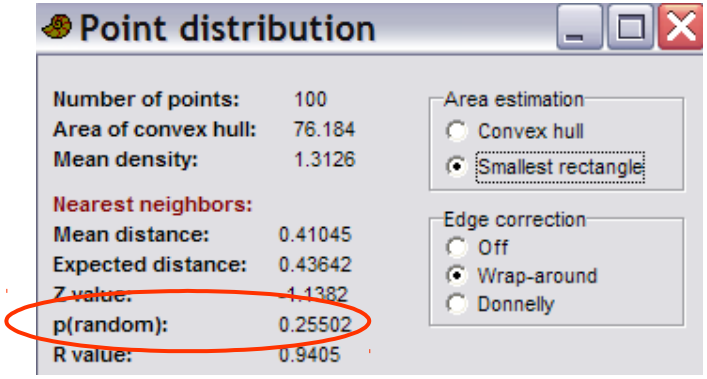


A random distribution within its convex hull



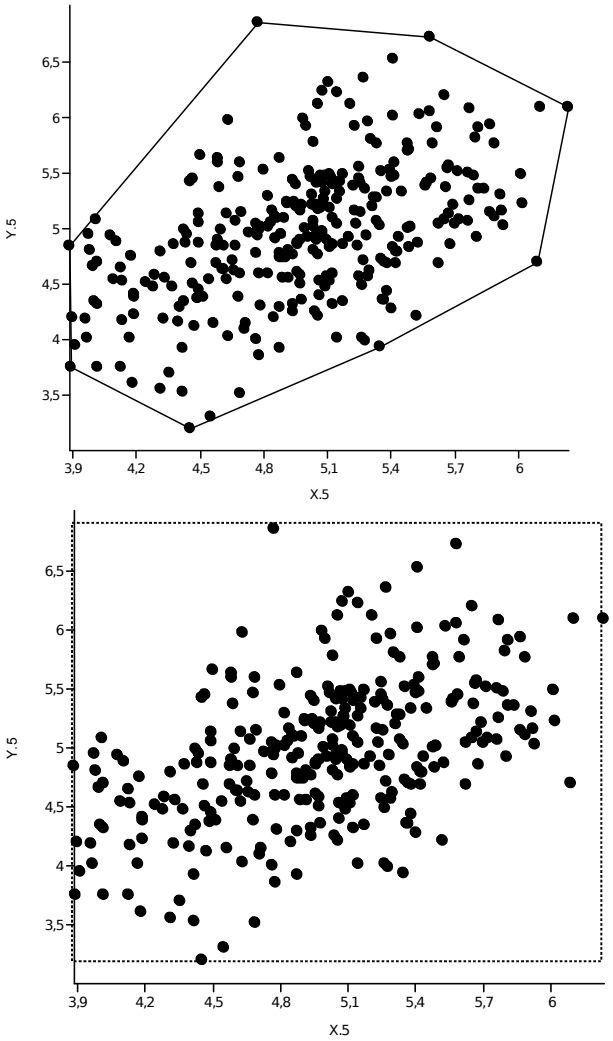
An random distribution within its smallest rectangle



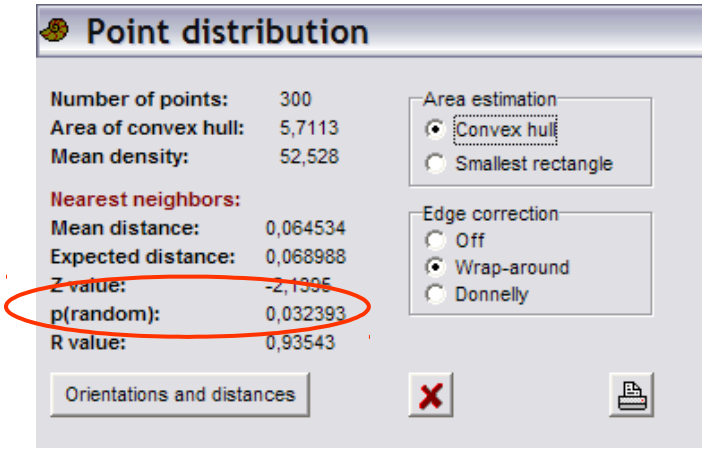


Testing spatial randomness

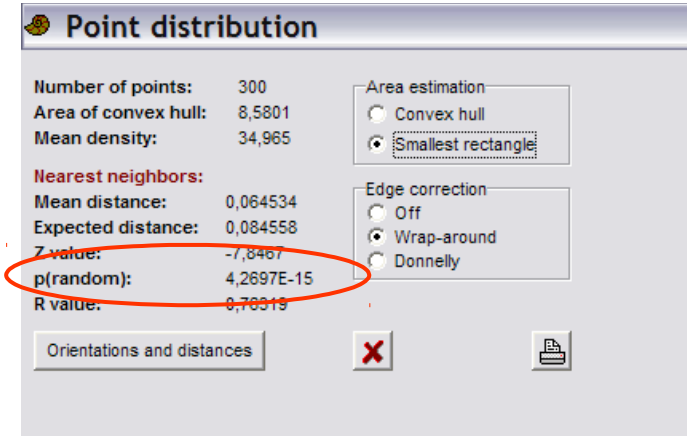
$$R = \frac{2\bar{d}}{\sqrt{A/N}},$$



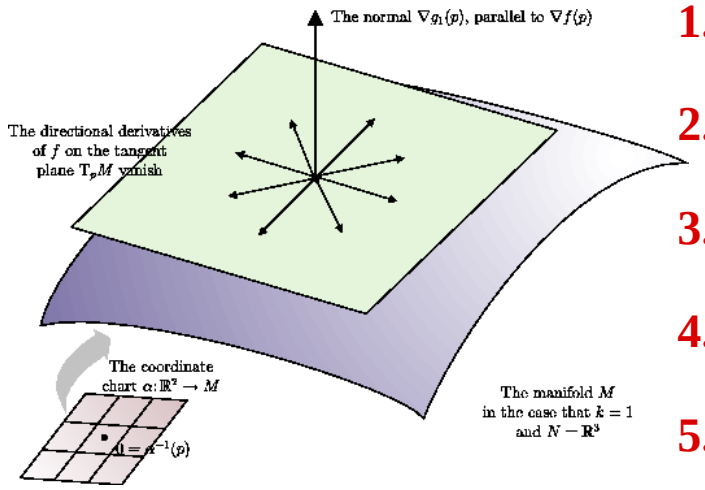
A bivariate normal distribution with mean= 5, and st. Dev = 0.5 within its convex hull



A bivariate normal distribution with mean = 5, and st. Dev= 0.5 within its smallest rectangle



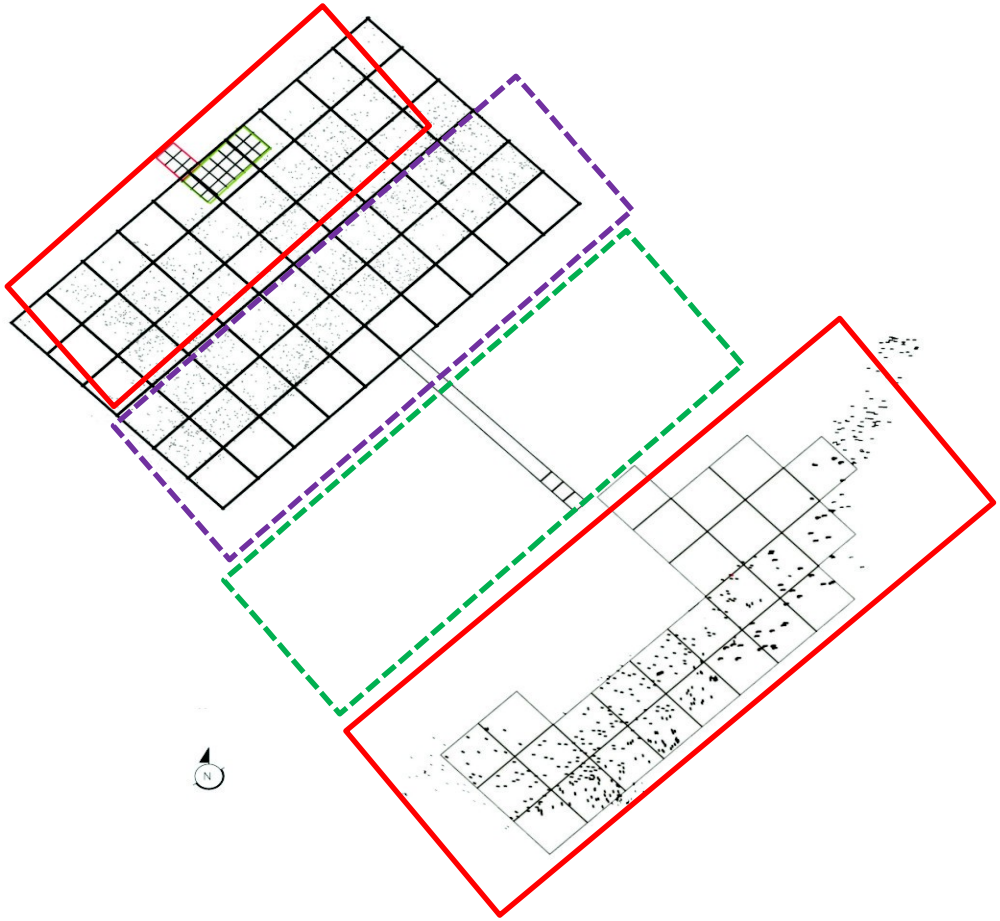
Additional Difficulties



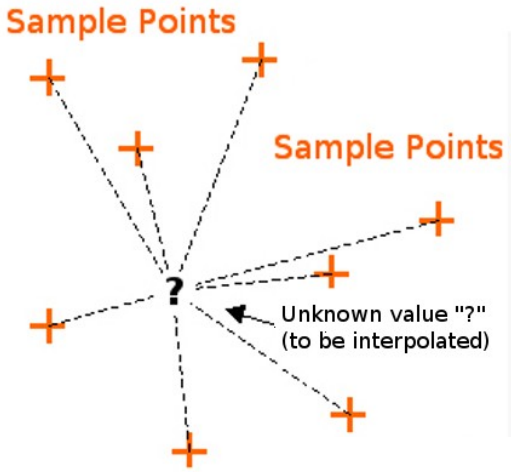
1. **From count data to spatial frequencies.**
2. **The problem of fragmentation**
3. **The problem of Categorization**
4. **The problem of incomplete sampling**
5. **The problem of post.depositional alteration**

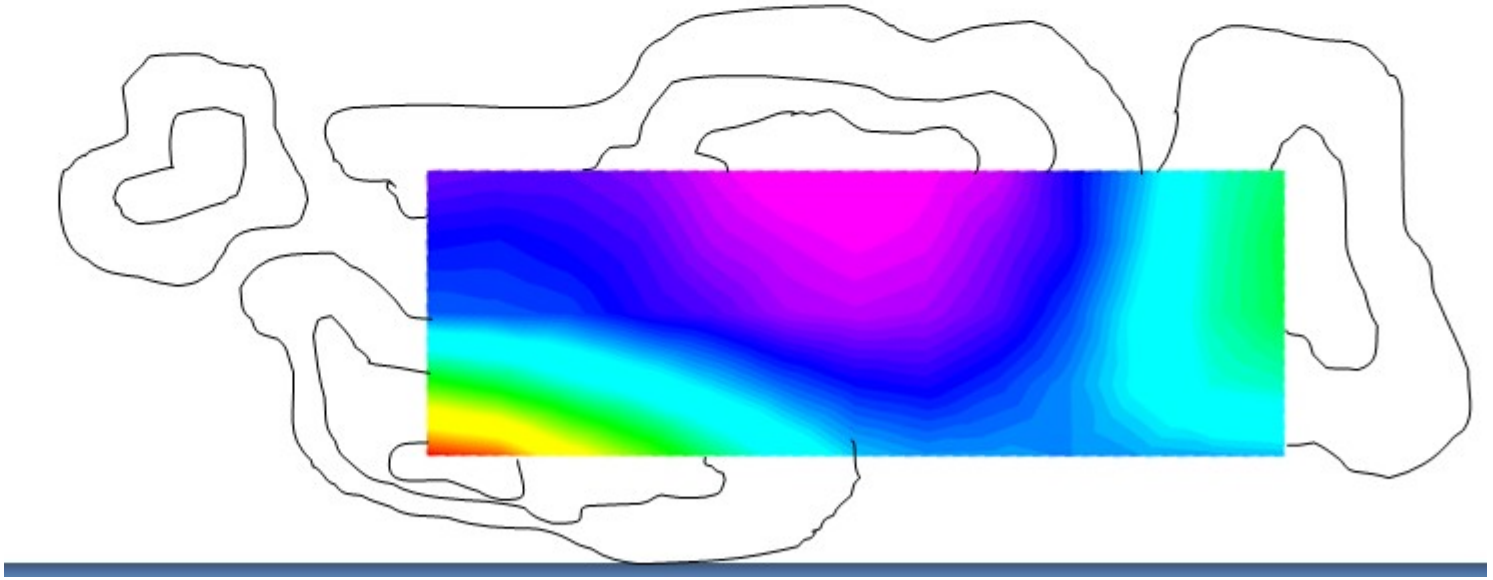
The probability an activity took place somewhere is determined by the abundance and density of the material consequences of that activity

Additional Difficulties.
4. The Problem of Incomplete Surveying



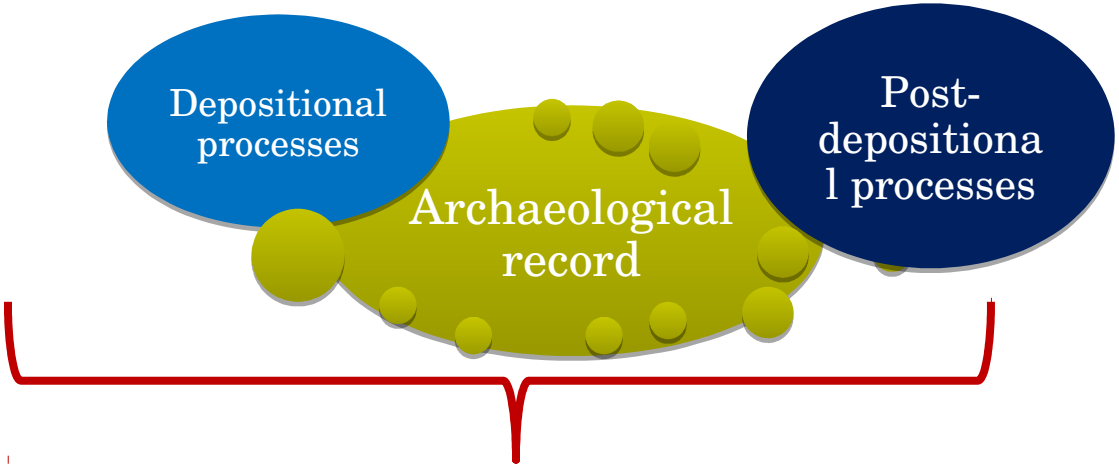
Additional Difficulties.
4. The Problem of Incomplete Surveying





Additional Difficulties.

5. The Problem of Post-Depositional Alteration

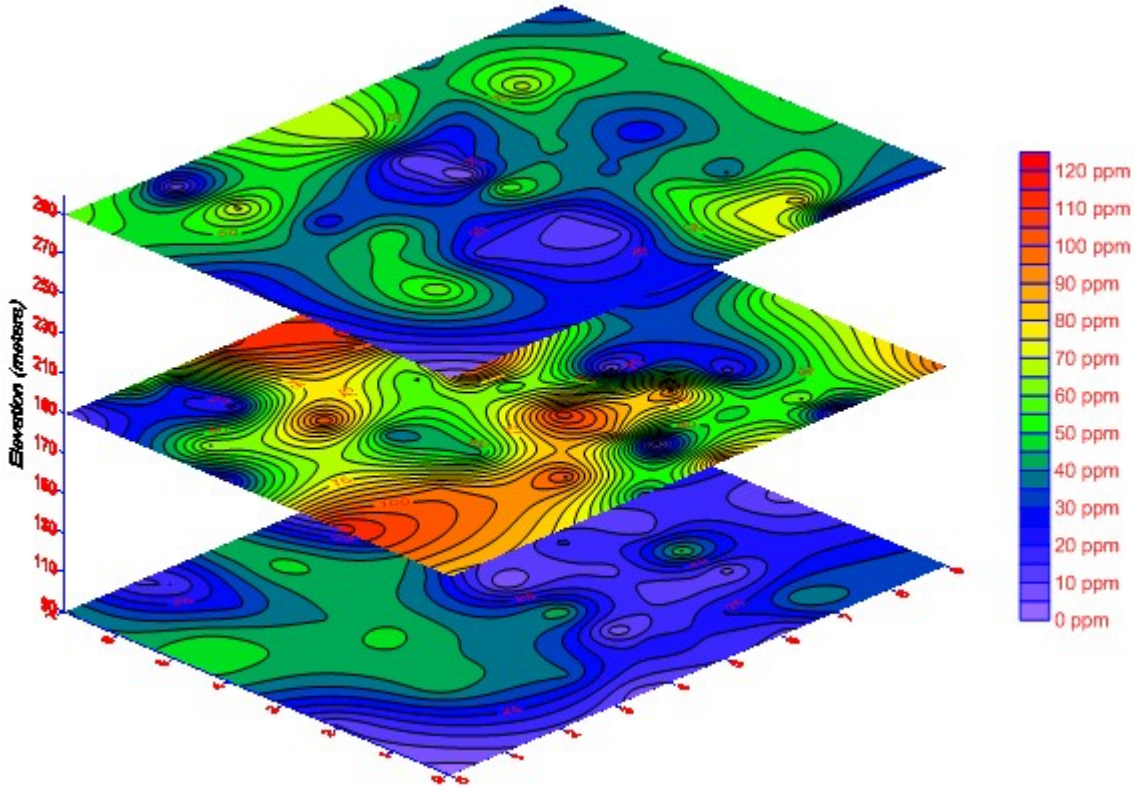


Pompeii Premise

≠

STUDY OF INTRA-SITE SPATIAL DISTRIBUTION OF THE PAST ALTERED EVIDENCE

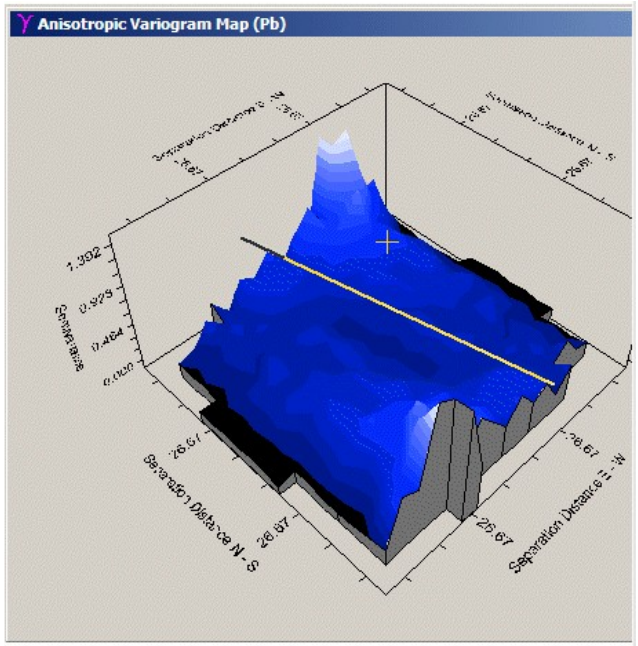
Additional Difficulties.
5. The Problem of Post-Depositional Alteration

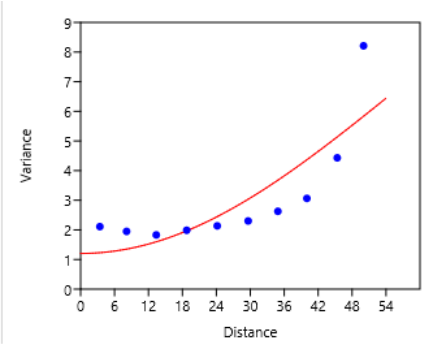


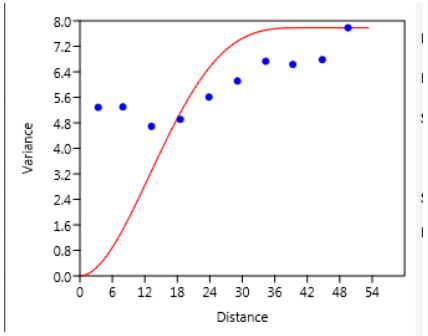
3D Layer overlaying. Spatial Correlation.

Additional Difficulties.
5. The Problem of Post-Depositional Alteration

Ground surface correlated Anisotropy





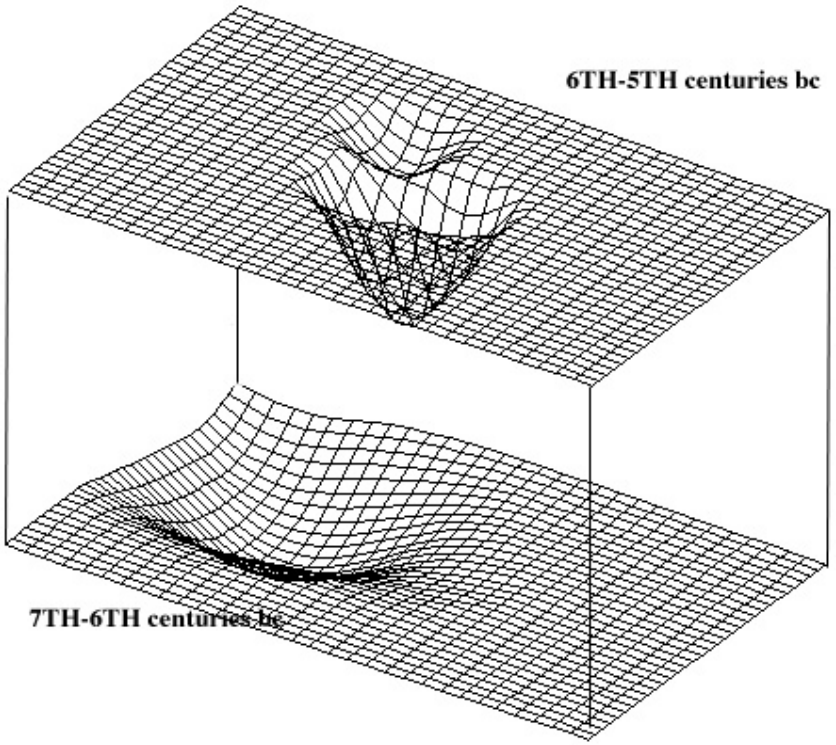


is not 3D interpolation. It is a 3D view of anisotropy
m different spatial gradients

Influence of Ground Surface on Spatial Distribution

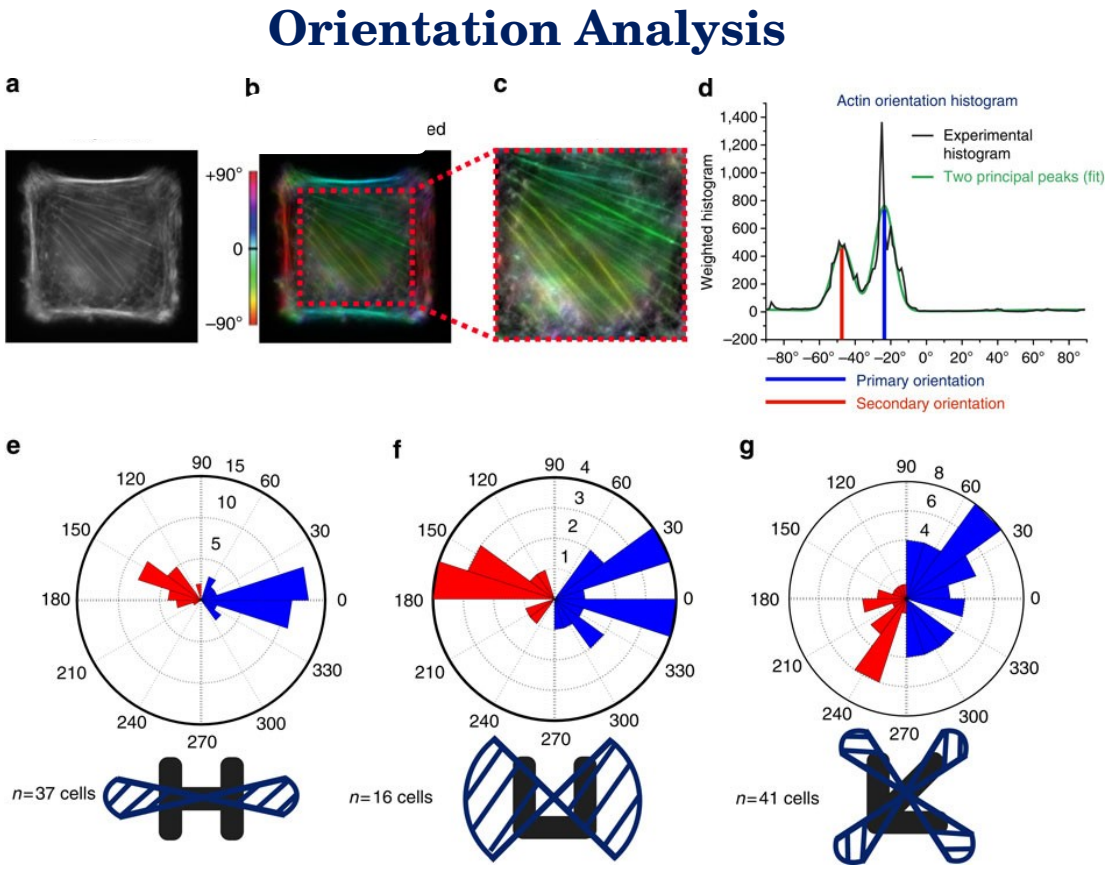
Additional Difficulties.
5. The Problem of Post-Depositional Alteration

Ground Surface-Abundance correlation



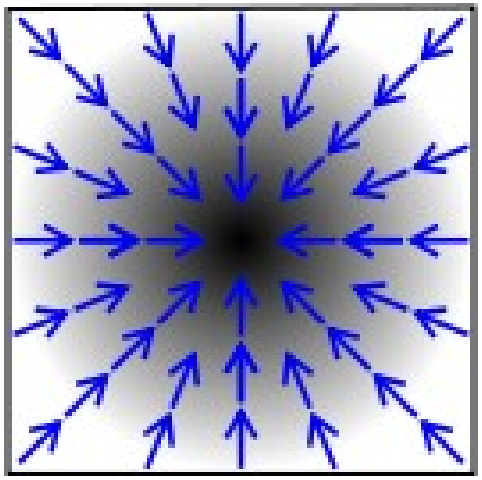
3D Layer overlaying. Spatial Correlation.

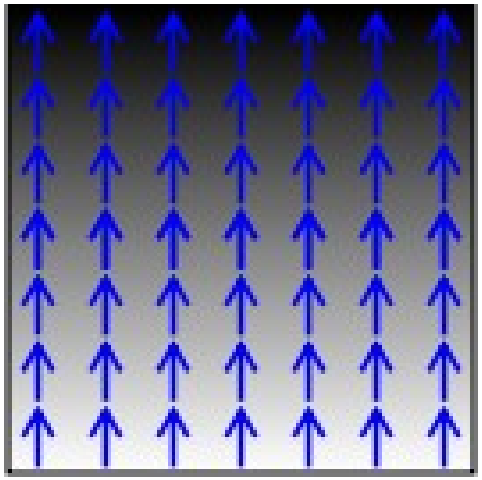
Additional Difficulties.
5. The Problem of Post-Depositional Alteration



Influence of Post-Depositional movement On Spatial Distribution

Other methods for analyzing Space and Time





GRADIENT (1st DERIVATIVE)

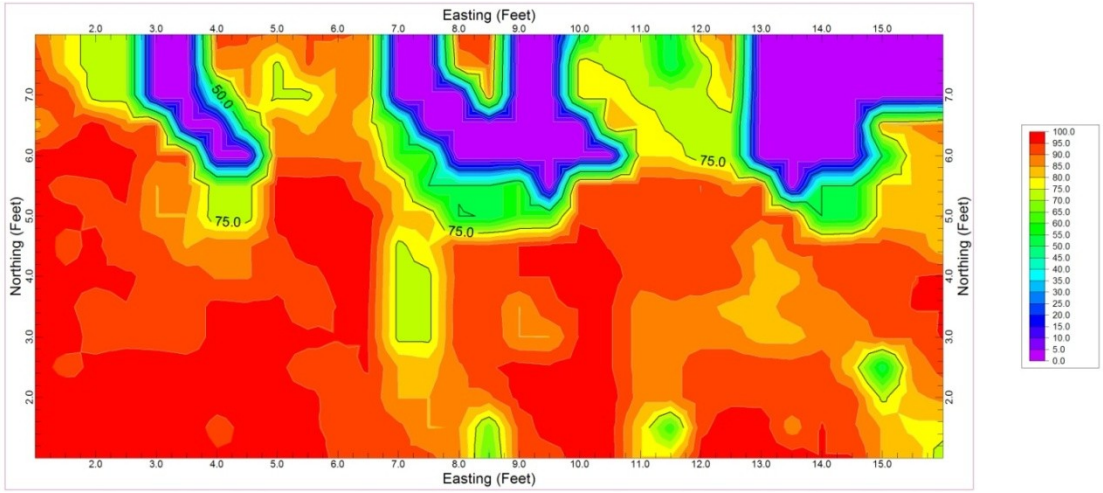
Determining the rate of spatial change

Looking for "directionality".

The **gradient** of a scalar field is a vector field that points in the direction of the greatest rate of increase of the scalar field, and whose magnitude is that rate of increase. In simple terms, the variation in space of any quantity can be represented (e.g. graphically) by a slope. The gradient represents the steepness and direction of that slope.

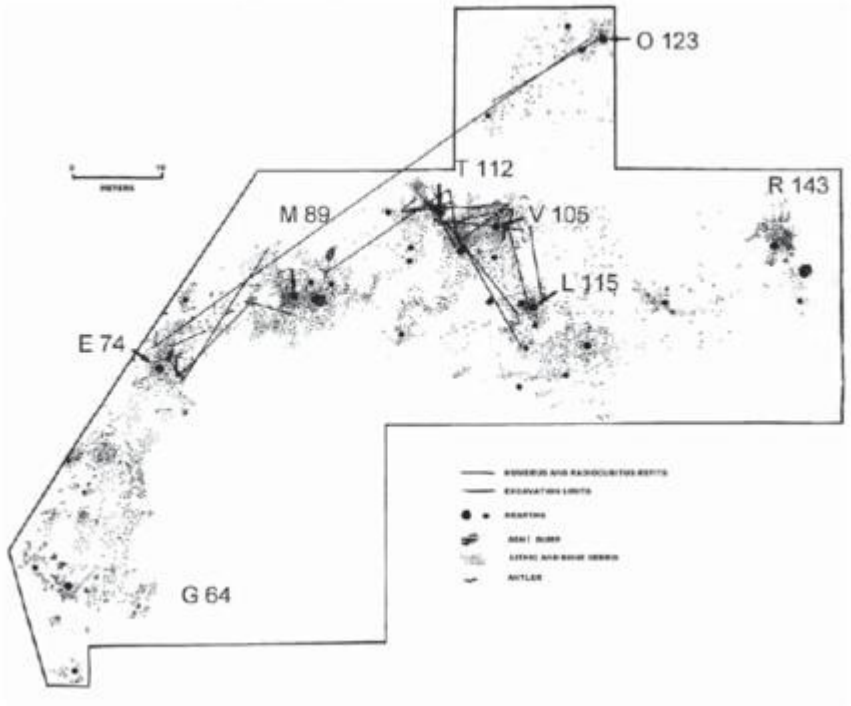
Gradient and directivity

5	2	0	0	0	6	0	0	0	0	1	1	0	0	0	0
10	2	0	0	1	3	0	0	0	0	3	2	0	0	0	0
21	21	5	0	0	6	1	0	0	0	0	0	0	0	0	1
26	11	6	2	2	27	3	0	1	0	11	11	5	0	1	4
7	22	10	2	8	15	1	0	9	19	6	0	3	6	10	13
31	21	12	4	22	13	0	2	13	14	1	0	5	2	5	0
74	33	46	23	28	14	4	5	10	29	6	5	14	10	4	2
0	14	15	22	9	13	2	9	7	0	3	4	33	13	0	0



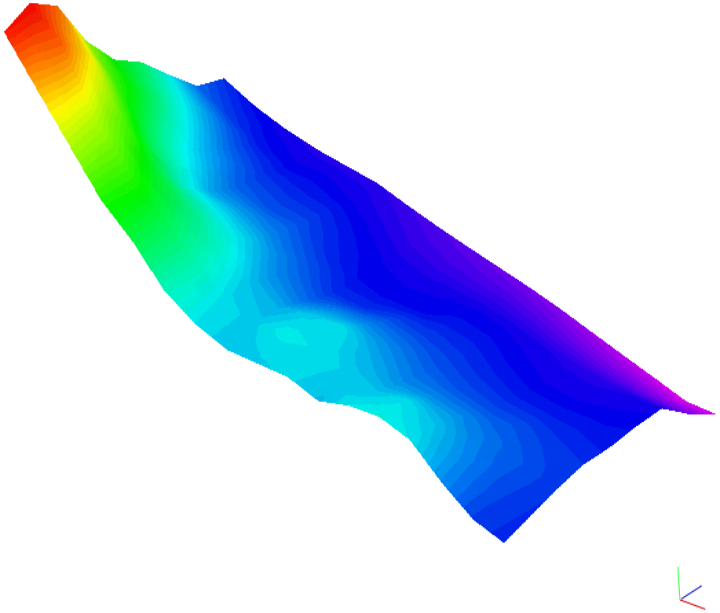
First derivative surface. Higher areas are the most stationary and the more probable location for slow expansion and high continuity

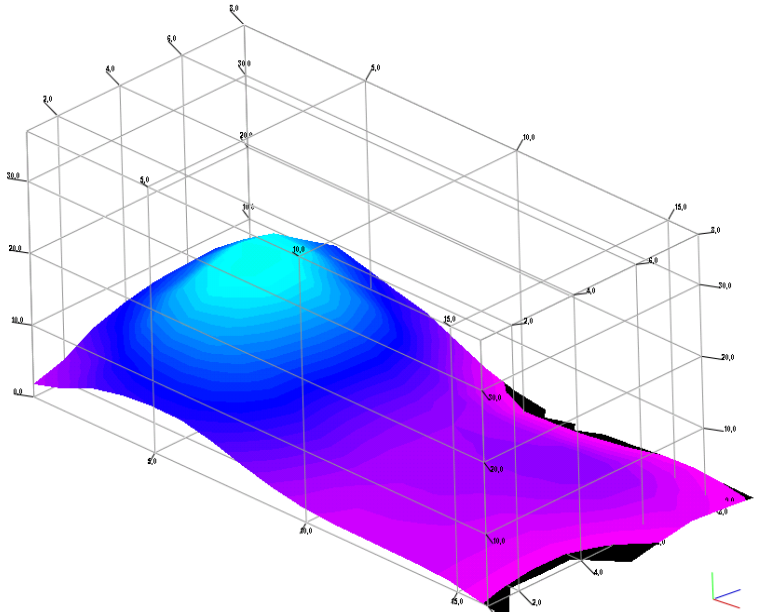
Additional Difficulties.
5. The Problem of Post-Depositional Alteration



The importance of refitting

A Case Study. A Patagonian Shell-Midden





Period 1

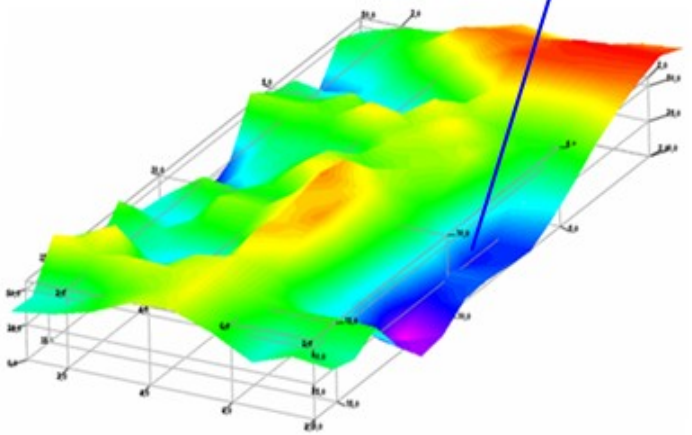
Period 2

Avian Remains

A Case Study. A Pataagonian Shell-Midden

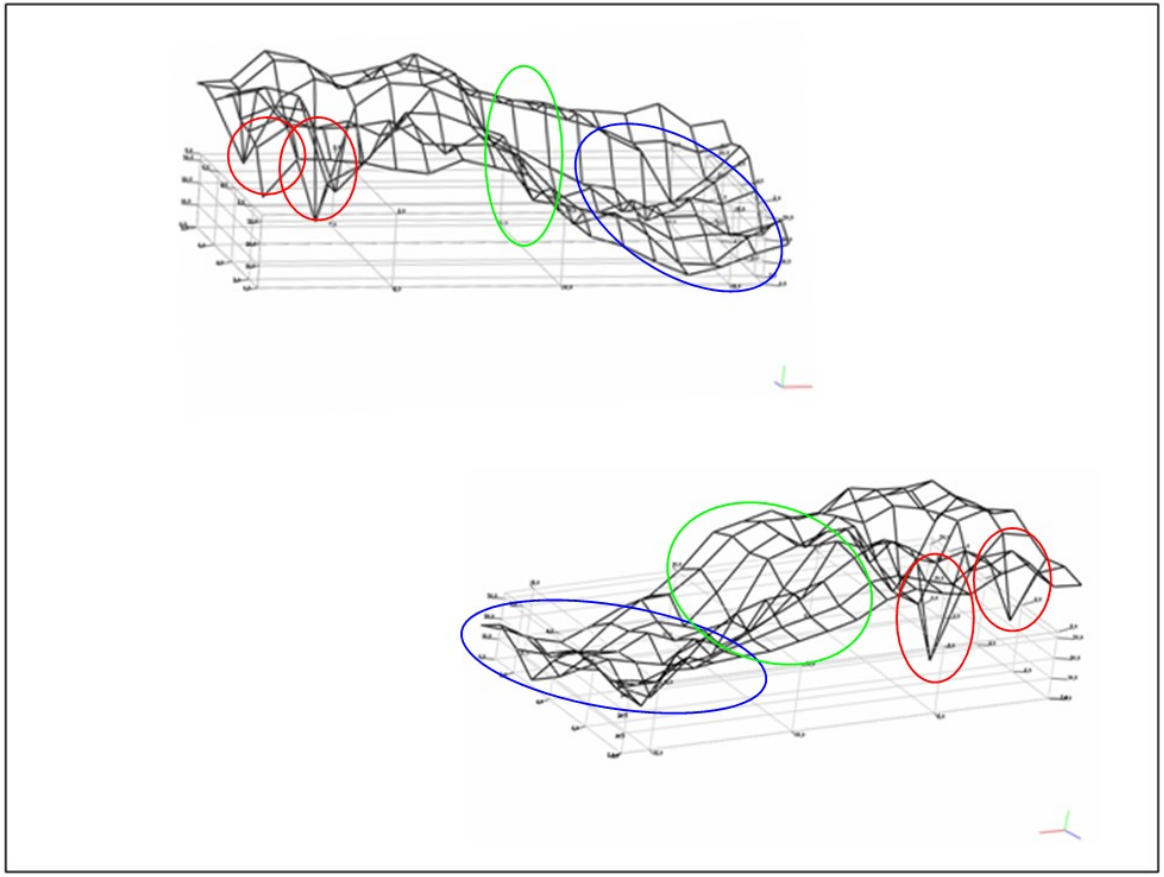
Tabla de Contingencia LOBO MARINO EPISODIO A

8	29	16	0	2	2	1	2	3	0	1	1	1	0	0	1	0
7	17	25	2	0	5	4	2	20	0	2	1	0	0	0	0	0
6	16	56	17	0	4	5	12	3	0	0	0	0	0	0	0	1
5	12	7	12	4	8	13	3	3	3	6	27	35	13	0	0	2
4	18	16	5	3	22	8	4	2	14	38	5	1	5	2	13	12
3	8	17	3	2	8	24	7	0	9	13	7	0	0	13	3	0
2	21	15	21	24	15	11	3	3	5	12	3	4	13	12	10	1
1	11	4	7	9	14	6	9	2	11	7	2	2	17	23	4	0
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**



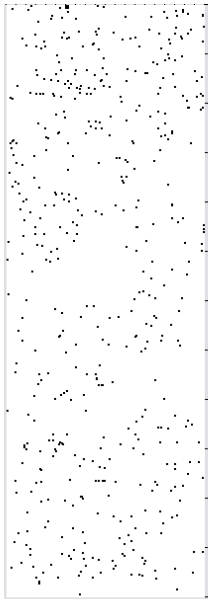
Sea-wolf bones (seals)
Period 1
Stationarity analysis

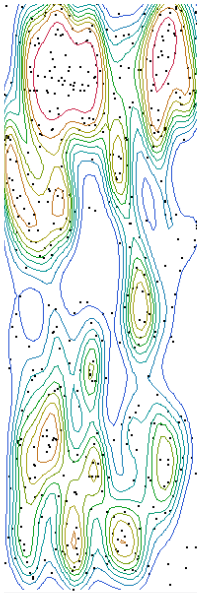
A Case Study. A Pataagonian Shell-Midden

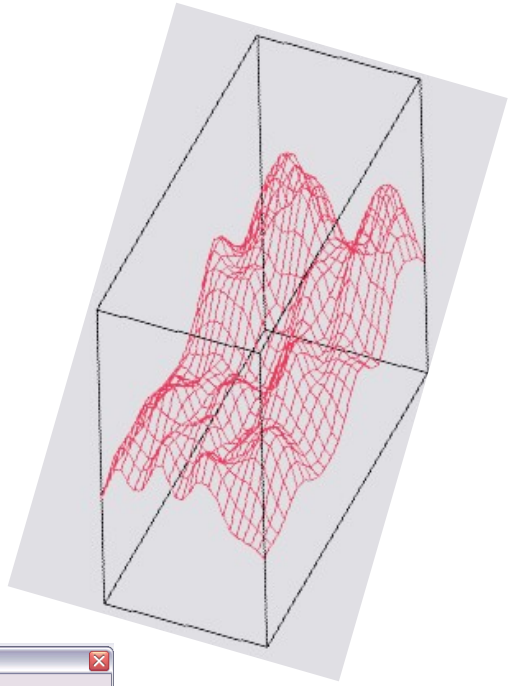


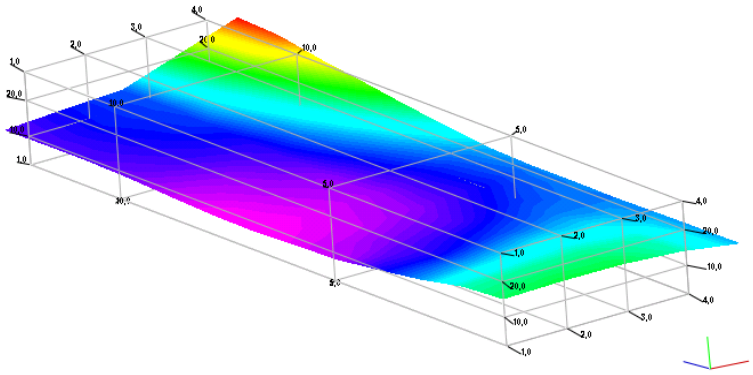
Sea-wolf bones (seals)
Period 2
Stationarity analysis

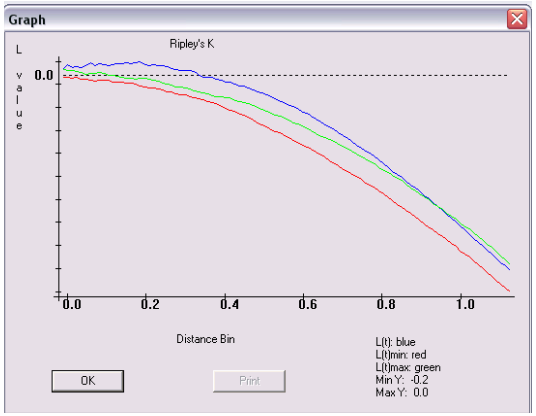
A Case Study. Historical Archaeology. A 19th century hillfort in Central Argentina





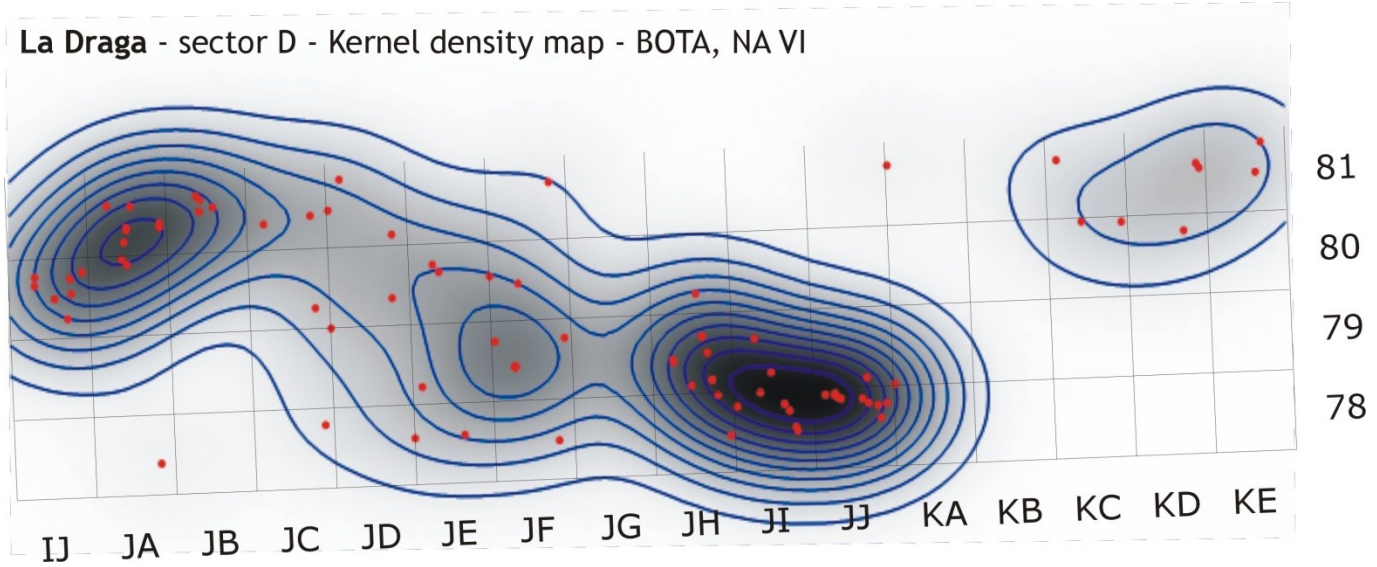






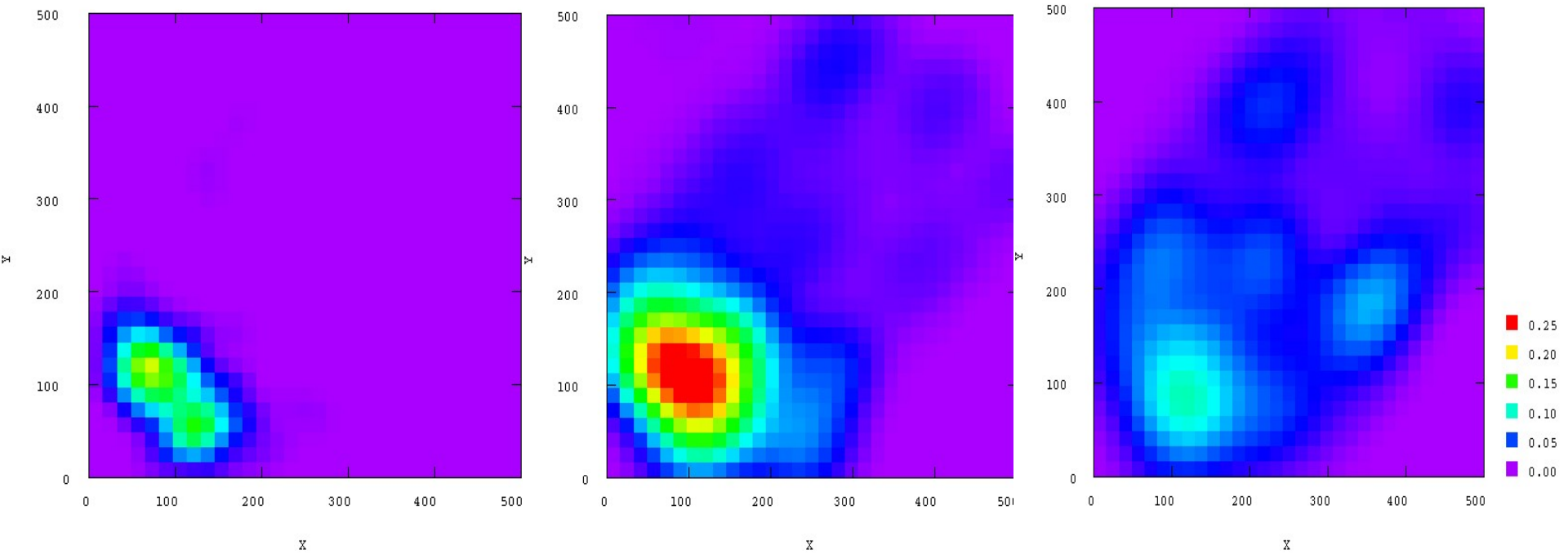
Random pattern

A Case Study. Historical Archaeology. Early Neolithic in Catalonia



Random pattern

A case study. Taphonomic Experimentation



Effects of scavenging on the frequency of bones (lama guanicoide). Controled Observations of animal carcasses during three years.

1st year: original distribution. Carcass not altered by scavengers

2nd year. Alteration. Scavengers concentrate some bones and spread others

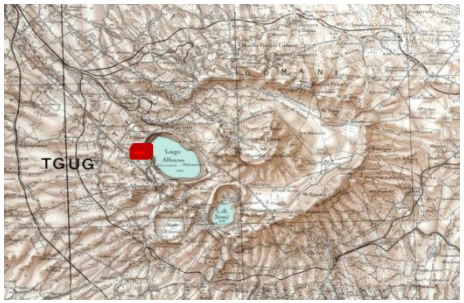
3rd year. More alteration. Spatial dispersal

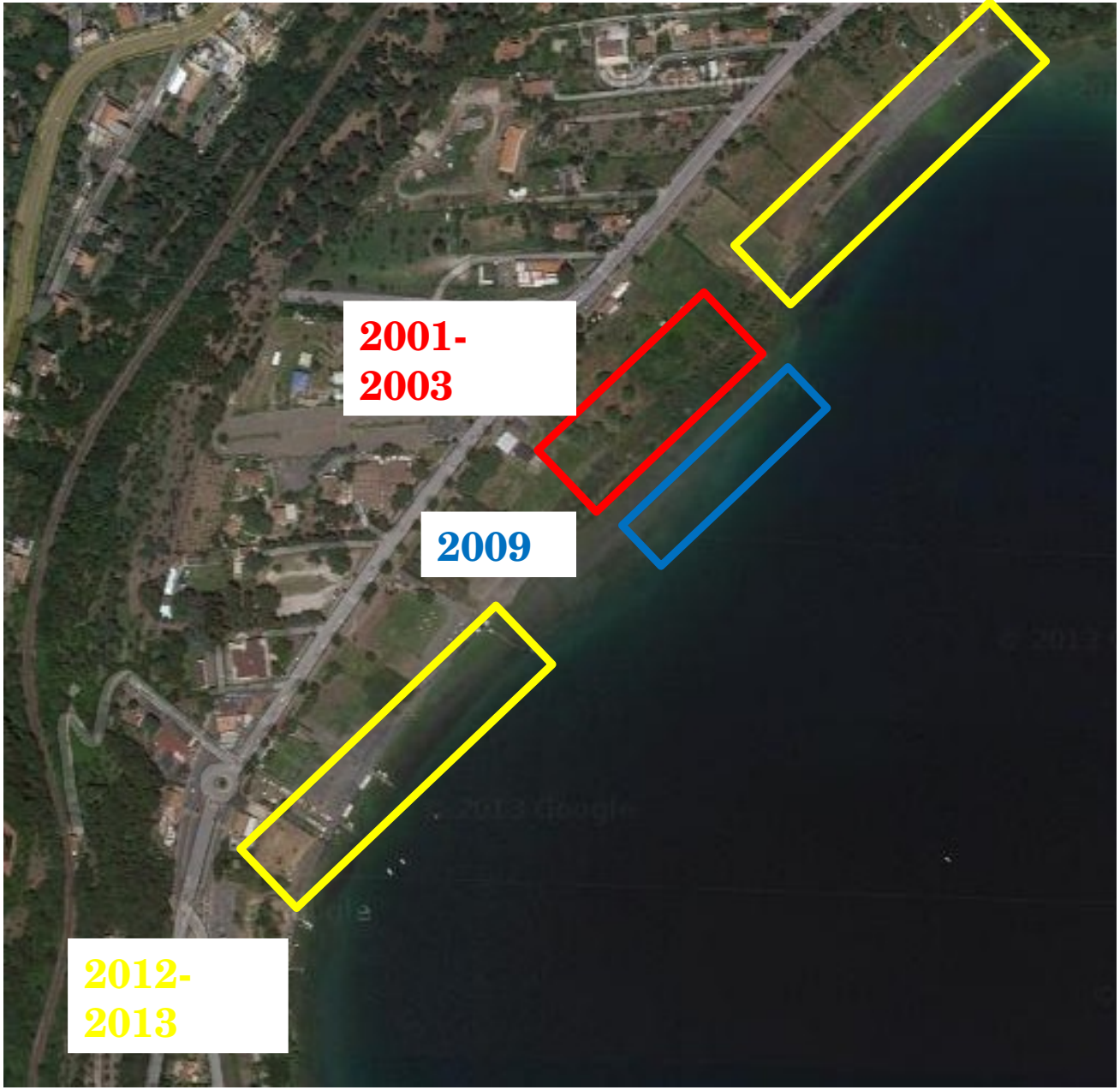
After: Mameli, Barceló and Estévez 2002.

PREDICTING THE ACCUMULATIVE CONSEQUENCES OF ABANDONMENT PROCESSES. INTRASITE ANALYSIS OF LAKESIDE SETTLEMENTS

ACHINO Katia F., ANGLE Micaela, BARCELÓ, Juan A.

VILLAGGIO DELLE MACINE(XIX-XVI B.C.)





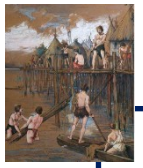
SURFACE SAMPLING

VILLAGGIO DELLE MACINE: SURFACE SURVEY DATA

MULTIPLE CAUSAL MECHANISMS PRODUCED THIS ARCHAEOLOGICAL RECORD

DISECTING THE PALIMPSEST

1) POST-DEPOSITIONAL ACTIVITIES
2) ABANDONMENT
3) ORIGINAL ACTIVITY DURING OCCUPATION



3) ORIGINAL ACTIVITY DURING OCCUPATION: HOW TO PREDICT THEIR SPATIAL LOCATION FROM SURFACE SURVEY DATA

PREDICTION CAN BE REALIZED THROUGH EXPLOITATION OF ACCUMULATION

HOW WE CAN MEASURE SPATIAL ACCUMULATION?

MAPPING THE SPATIAL DISTRIBUTION OF THE MATERIAL EVIDENCES

X	Y	Frequencies

X

Y

0 – 0
CENTROID

INTERPRETING THE SPATIAL DISTRIBUTION

1	0	2
2	1	7
0	3	0

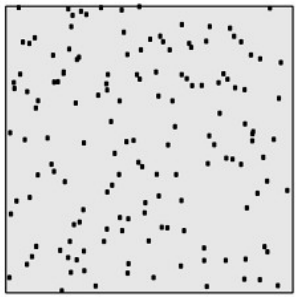
1	0	2
2	1	7
0	3	0

ACCUMULATION

HOMOGENEITY

RANDOMNESS

RESULTS OF NATURAL AND CULTURAL PROCESSES



a Random

STATISTICAL REJECTION OF THE HOMOGENEITY HYPOTHESIS

INTERPRETING THE SPATIAL DISTRIBUTION

POISSON DISTRIBUTION AS NULL HYPOTHESIS: ABSENCE OF ACCUMULATION

ABSENCE OF ACCUMULATION

SPATIAL HOMOGENEIZATION OF THE MATERIAL EVIDENCES

EFFECT OF POST-DEPOSITIONAL PROCESS **(IN OUR CASE-STUDY)**

Decreases ENTROPY

PRESENCE OF ACCUMULATION

DEPARTURES OF SPATIAL HOMOGENEITY

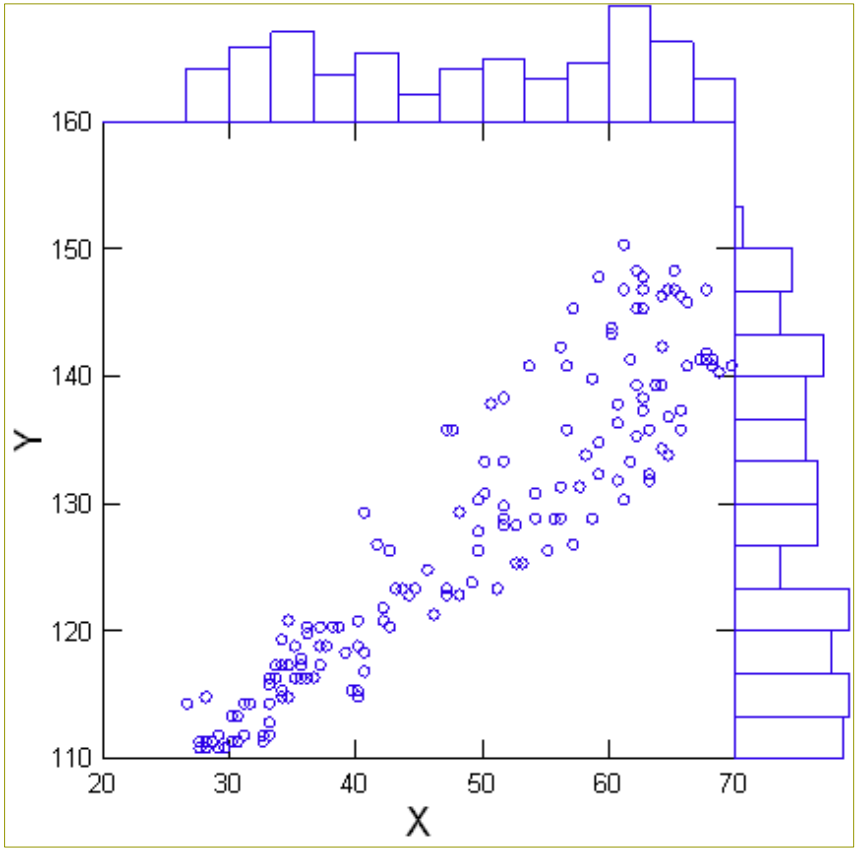
IT CAN BE EVIDENCE OF ORIGINAL SPACE STRUCTURE PRESERVATION

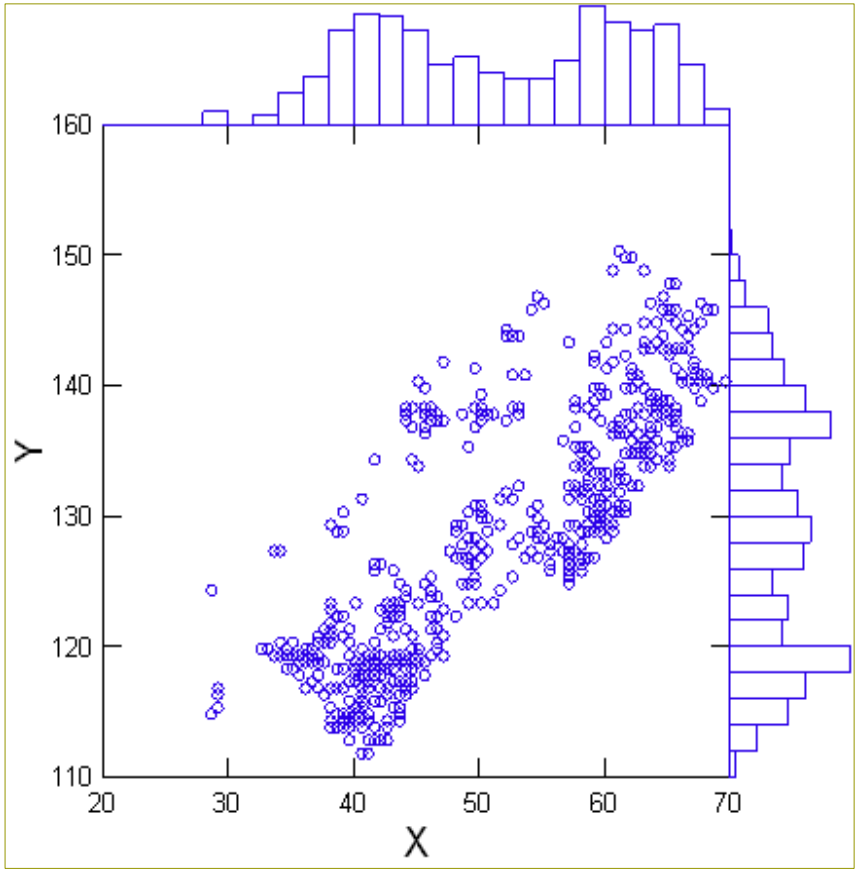
Increases ENTROPY

FAUNAL REMAINS: AREA 2001

POSTS: AREA 2001

PRESENCE/ABSENCE ANALYSIS



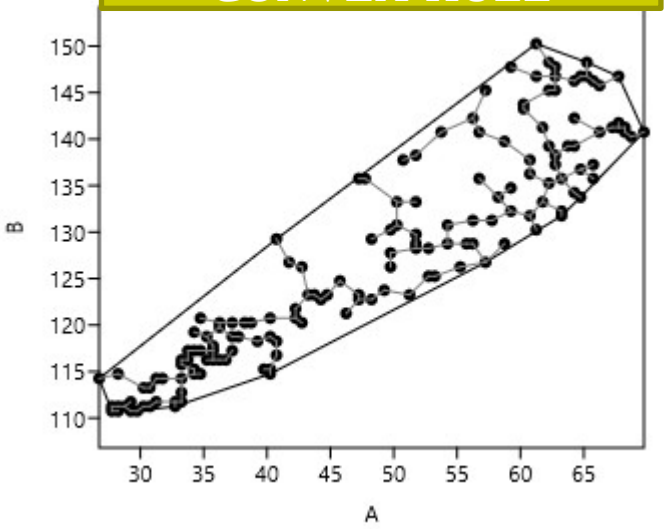


FAUNAL REMAINS: AREA 2001

POSTS: AREA 2001

NEAREST-NEIGHBOURS ANALYSIS

CONVEX-HULL



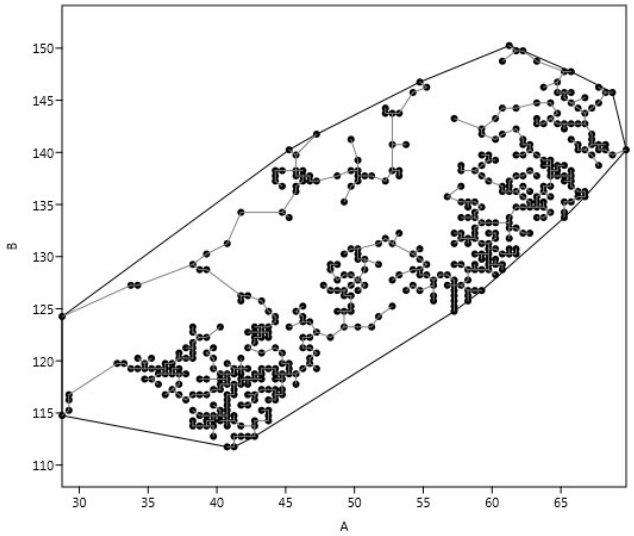
Number of points: 154
Area: 594,38
Mean density: 0,2591

Nearest neighbours analysis with wrap-around edge correction
Mean distance: 0,99508
Expected distance: 0,98229
***R*:** 1,013
***Z*:** 0,30909 ***p* (random):** 0,75726

The null hypothesis of a random pattern (Poisson process) can not be rejected at $p<0.05$

This is a consequence of exhaustive survey within the study micro-area

CONVEX-HULL



Number of points: 496
Area: 810,38
Mean density: 0,61206

Nearest neighbours analysis with Donnelly´s edge correction
Mean distance: 0,61556
Expected distance: 0,65617
***R*:** 0,9381
***Z*:** -2,5136 ***p* (random):** 0,011951

There is statistically significant clustering

This is the result of assuming an absence of data at non surveyed areas

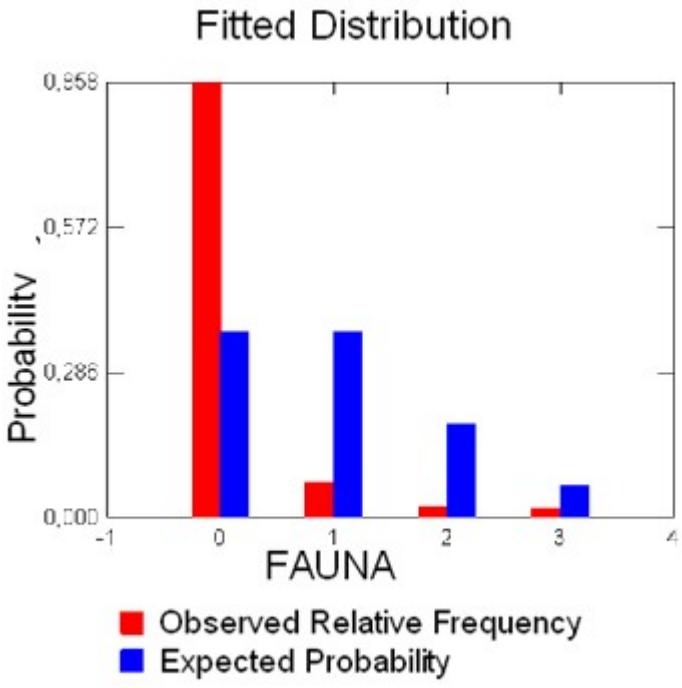
FAUNAL REMAINS: AREA 2001

POSTS: AREA 2001

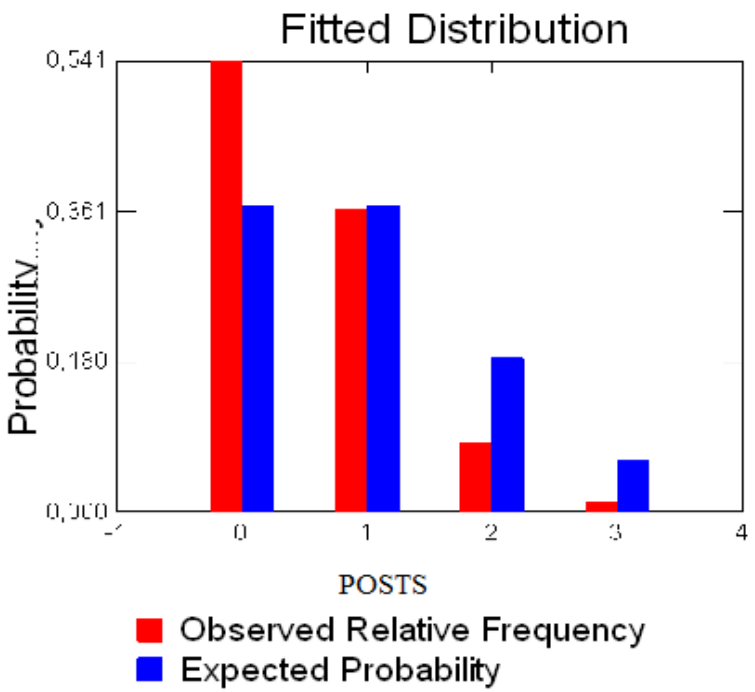
ANALYSIS OF SPATIAL FREQUENCIES and not only the density of spatial presence location points

Kolmogorov-Smirnov Test

$$\widehat{F_n}(x) = \frac{1}{n}\sum_{i=1}^{n} I_{X(i)\leq x}$$



***with* $\lambda = 1$ the spatial distribution of our data do not fit the Poisson distribution**

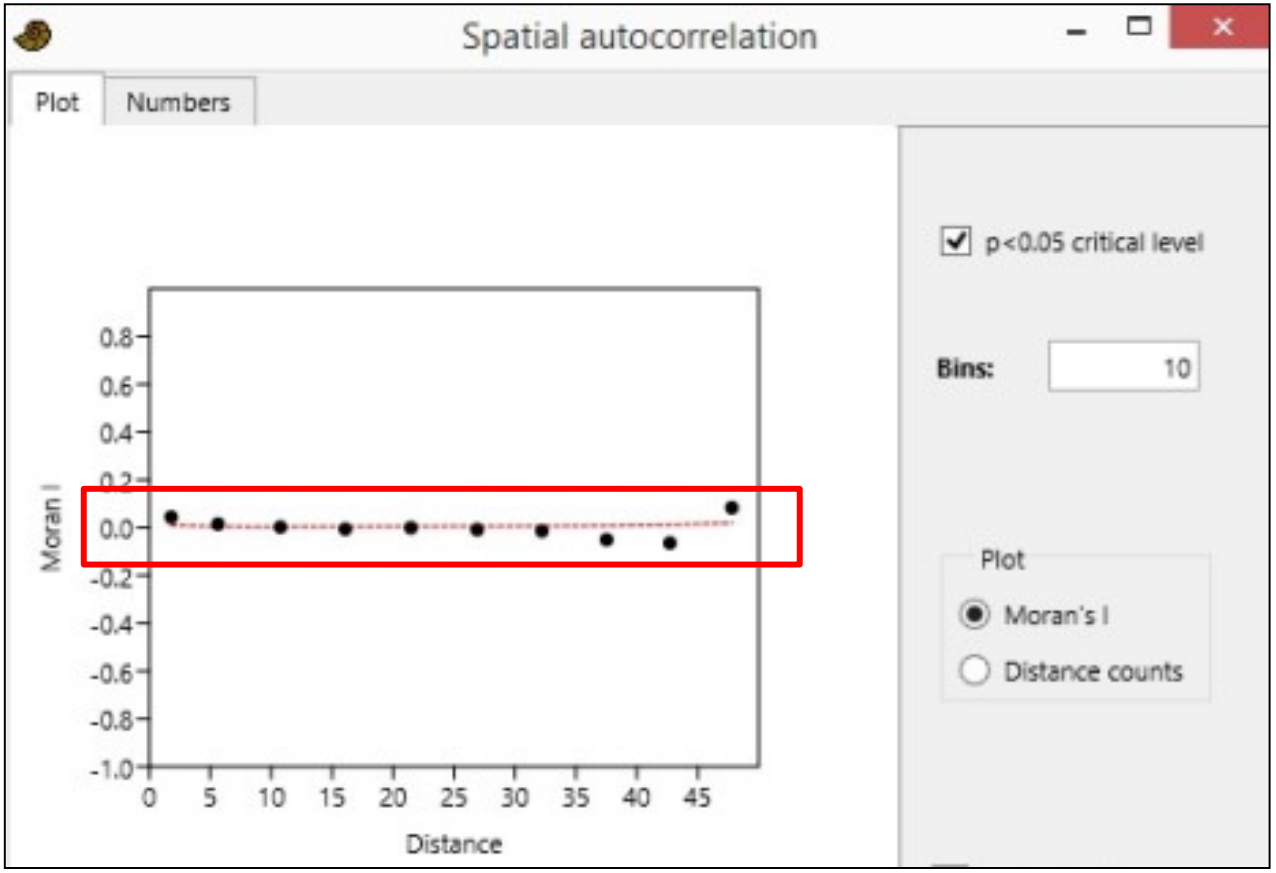


Kolmogorov-Smirnov Test	**0,49**
p-Value	**0**

Kolmogorov-Smirnov Test	**0,173**
p-Value	**0**

FAUNAL REMAINS: AREA 2001

POSTS: AREA 2001



I= 0
ABSENCE OF SPATIAL AUTOCORRELATION

THERE IS A SIGNIFICANT DEPARTURE OF THE HYPOTHESIS OF SPATIAL HOMOGENEITY MORAN'S I

Multinormality. Mardia Test

FAUNAL REMAINS: AREA 2001

POSTS: AREA 2001

$$b_{2,d} = \frac{1}{n}\sum_{i=1}^{n}[(X_i - \mu)' S^{-1} (X_i - \mu)]$$

Mardia tests

Parameter	Value	Statistic	df	*p* (normal)
Skewness:	47,3	8537	10	0
Skewness, small sample corrected:		8573	10	0
Kurtosis:	73,38	175,4		0

Doornik and Hansen omnibus

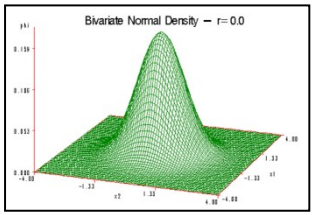
E_D:	1,521E04
p (normal):	0

Mardia tests

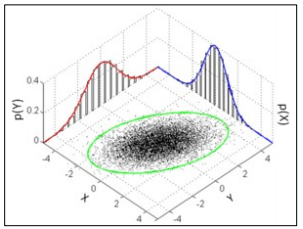
Parameter	Value	Statistic	df	*p* (normal)
Skewness:	1,681	303,4	10	2,9E-59
Skewness, small sample corrected:		304,7	10	1,568E-59
Kurtosis:	13,68	-3,974		7,074E-05

Doornik and Hansen omnibus

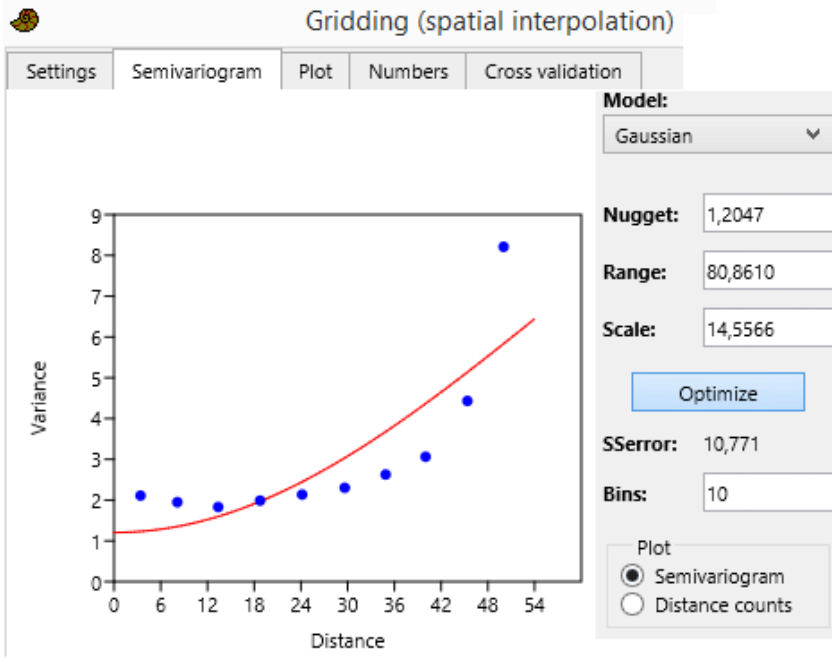
E_D:	555,7
p (normal):	8,381E-117



SIGNIFICANT DEPARTURE OF THE BI-NORMALITY'S CONDITION: THERE IS NOT A SINGLE INTENTIONAL ACCUMULATION

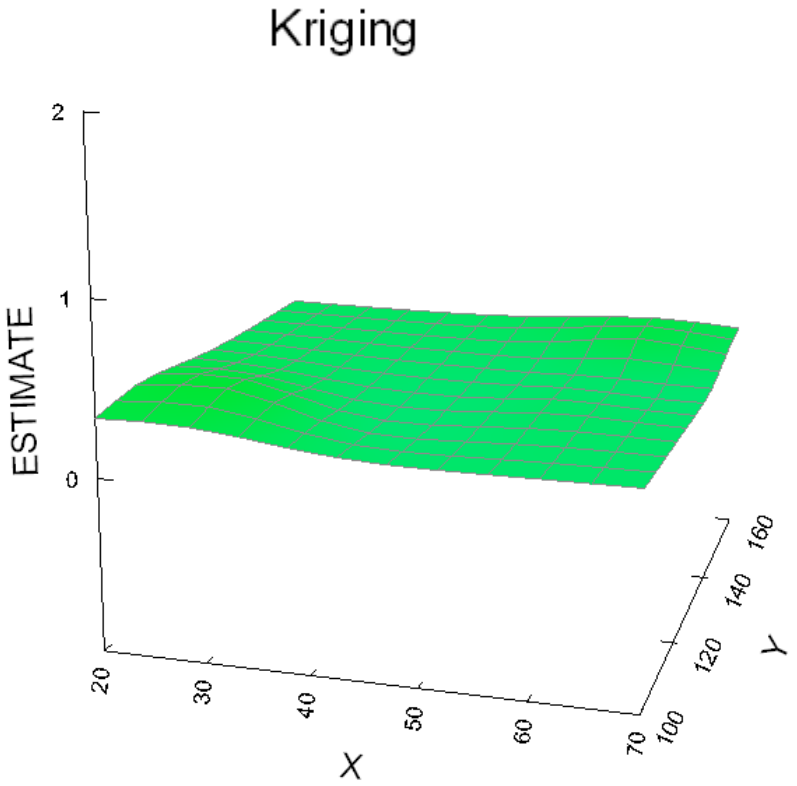


FAUNAL REMAINS: AREA 2001



1)Small nugge effect
2) Function increasing at the asymptote: when the distance h increase, also increase the variance. Two accumulations in two far from areas, in the two extremes of the investigated area.
3)Medium level of spatial irregularity due to fragmentation
4)Classical model of accumulation: majority of finds in two areas where the accumulation activity took place and in the surrounding.

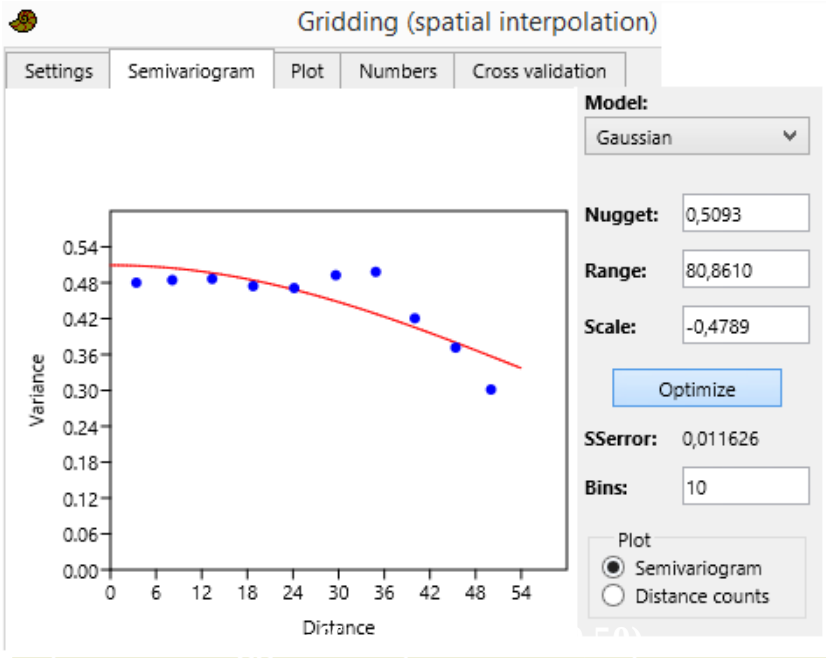
SPATIAL PREDICTIONS



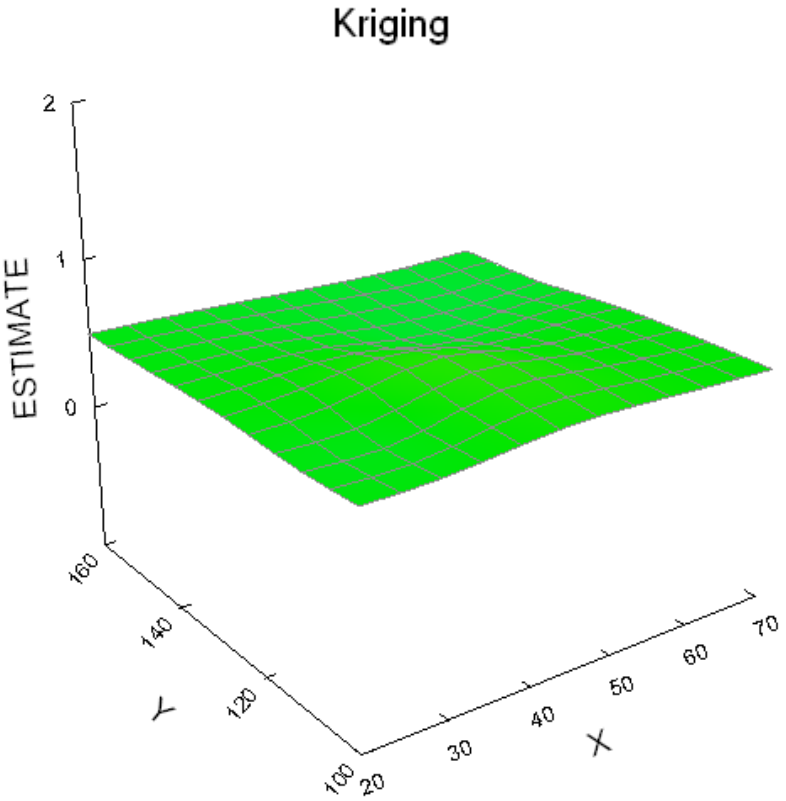
Differential accumulations of faunal remains and a significant empty area between both accumulations

POSTS: AREA 2001

SPATIAL PREDICTIONS



2)The population is distributed according to a more standard function.
3)The higher values are concentrated in the first portion of the function (from 0 to 24) and then they decrease.
4)The variance decrease in correspondence with the increase of the distance between points.
5)The function shows a linearity (posts alignments): spatial connectivity due to the partial preservation of ancient built structures

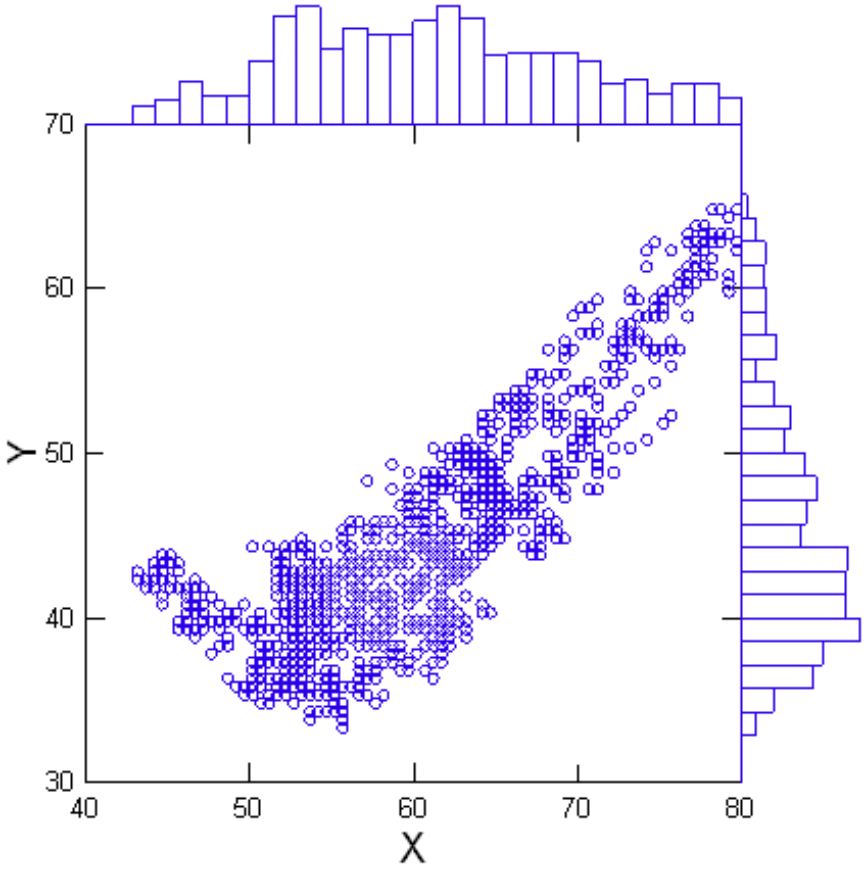


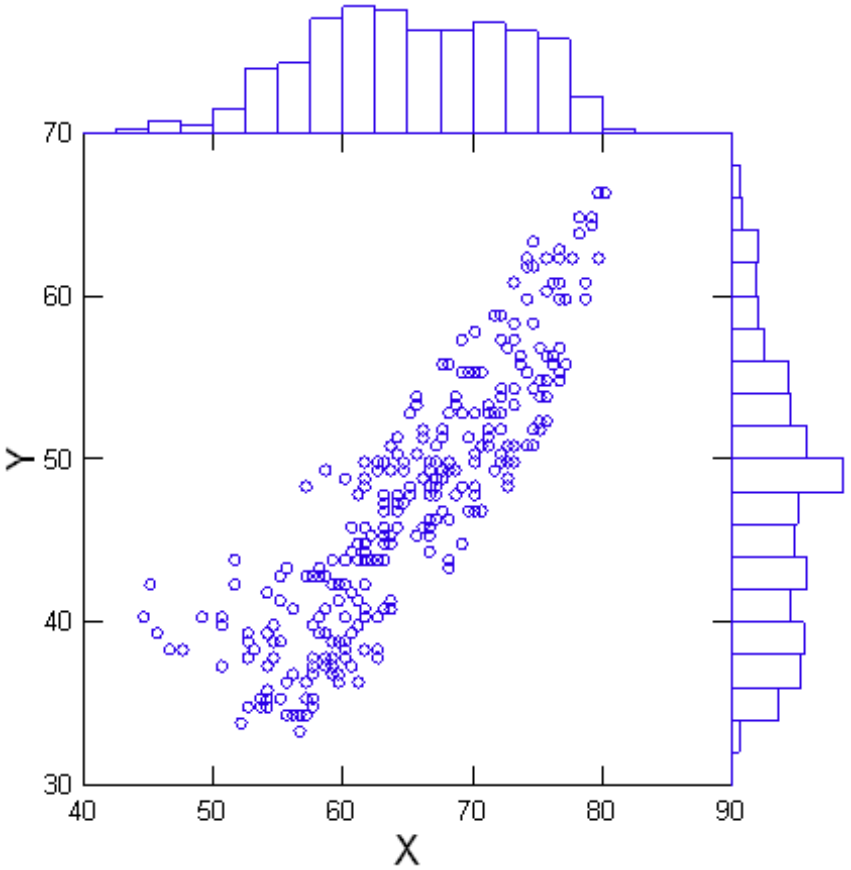
Differential accumulations of posts and a significant empty area between both accumulations

FAUNAL REMAINS: AREA 2009

Posts: AREA 2009

PRESENCE/ABSENCE ANALYSIS





Multinormality. Mardia Test

FAUNAL REMAINS: AREA 2009

Posts: AREA 2009

$$b_{2,d} = \frac{1}{n}\sum_{i=1}^{n}[(X_i - \mu)' S^{-1} (X_i - \mu)]$$

Mardia tests

Parameter	Value	Statistic	df	*p* (normal)
Skewness:	13,35	2966	10	0
Skewness, small sample corrected:		2976	10	0
Kurtosis:	31,19	53,96		0

Doornik and Hansen omnibus

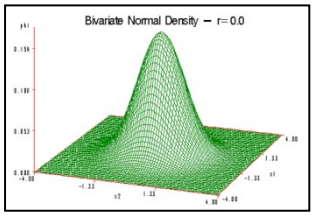
E_p:	3606
p (normal):	0

Mardia tests

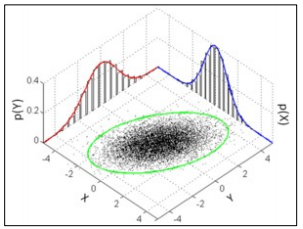
Parameter	Value	Statistic	df	*p* (normal)
Skewness:	5,882	1279	10	1,12E-268
Skewness, small sample corrected:		1284	10	1,249E-269
Kurtosis:	18,7	12,19		0

Doornik and Hansen omnibus

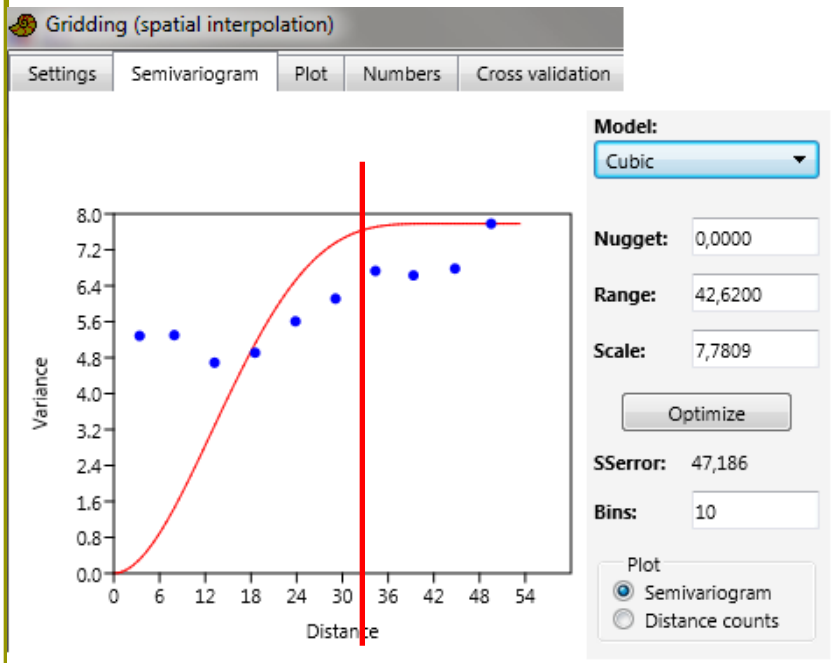
E_p:	2682
p (normal):	0



SIGNIFICANT DEPARTURE OF THE BI-NORMALITY'S CONDITION: THERE IS NOT A SINGLE INTENTIONAL ACCUMULATION

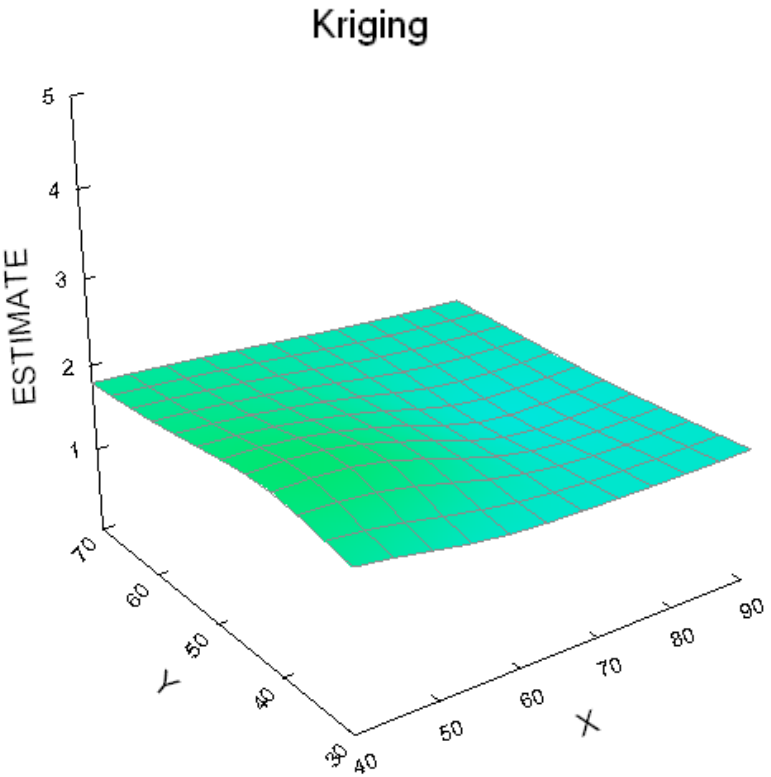


FAUNAL REMAINS: AREA 2009



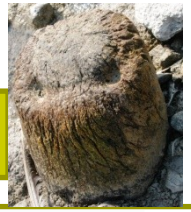
1) **Increasing monotonic function: when the distance h increase, also the variance increase.**
2) **The function start from the 0-0 but the points are attested from 4.8.**
3) **An area of faunal remains' accumulation is recognized while the surrounding shows high rate of empty areas: classical model of accumulation.**

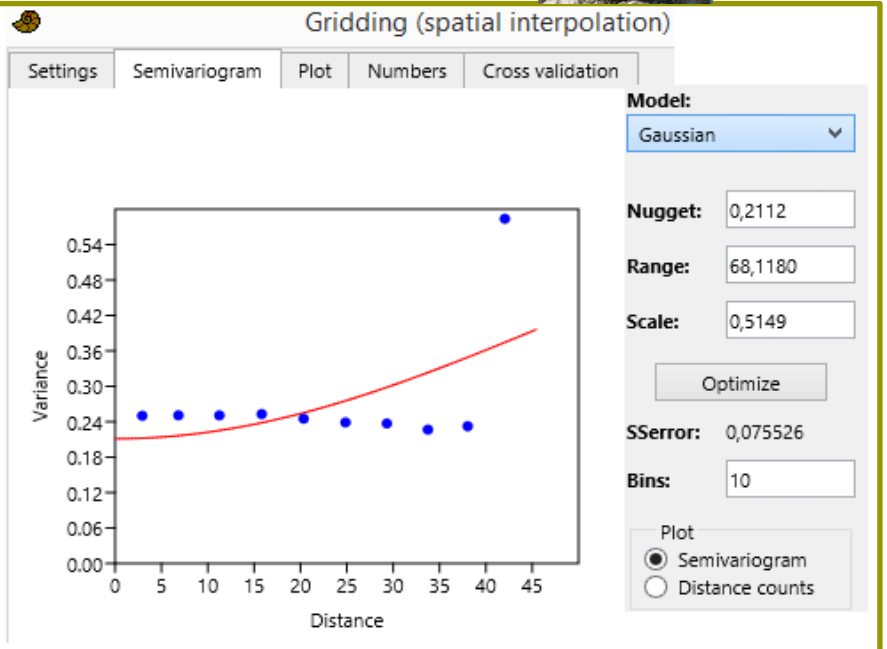
SPATIAL PREDICTIONS



Differential accumulations of faunal remains and a significant empty area between both accumulations

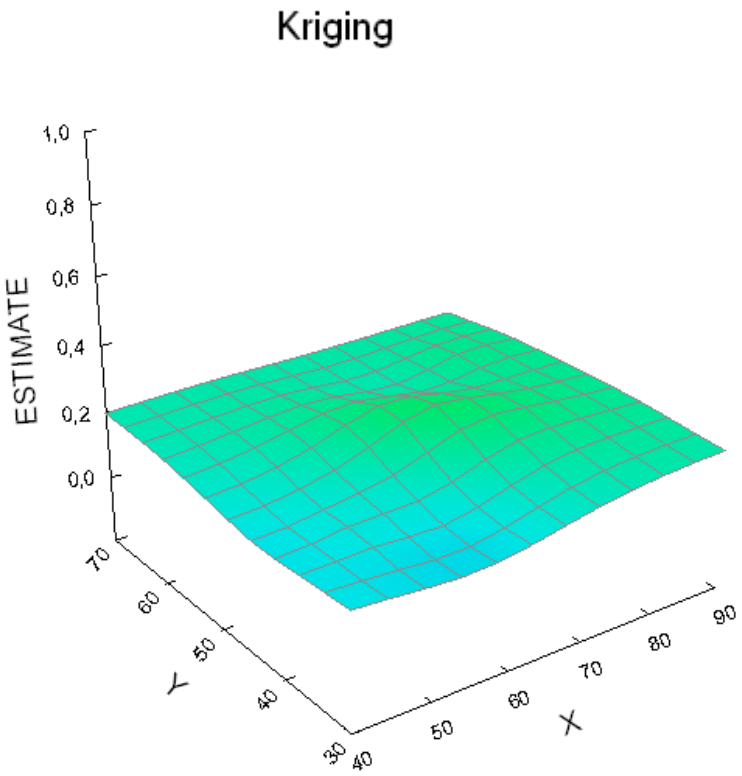
Posts: AREA 2009





1)Small nugge effect (from 0 to 0,20).
2)The population is distributed according to a more standard function.
3)The higher values are concentrated in the first portion of the function (from 0 to 15) and then they decrease.
4)The variance decrease in correspondence with the increase of the distance between points.
5)The function shows a linearity (posts alignments)
6)One outlier is also attested.

SPATIAL PREDICTIONS



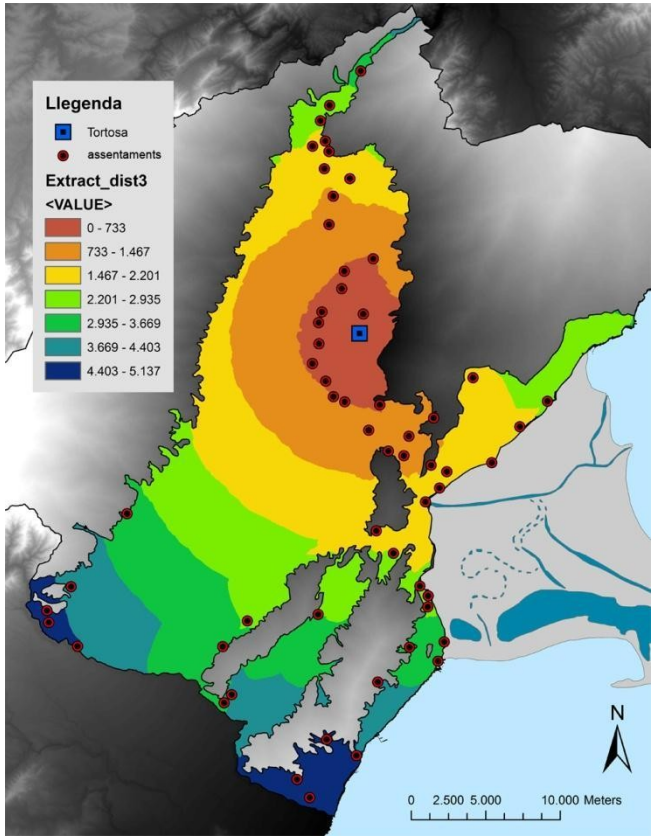
Differential accumulations of posts and a significant empty area between both accumulations

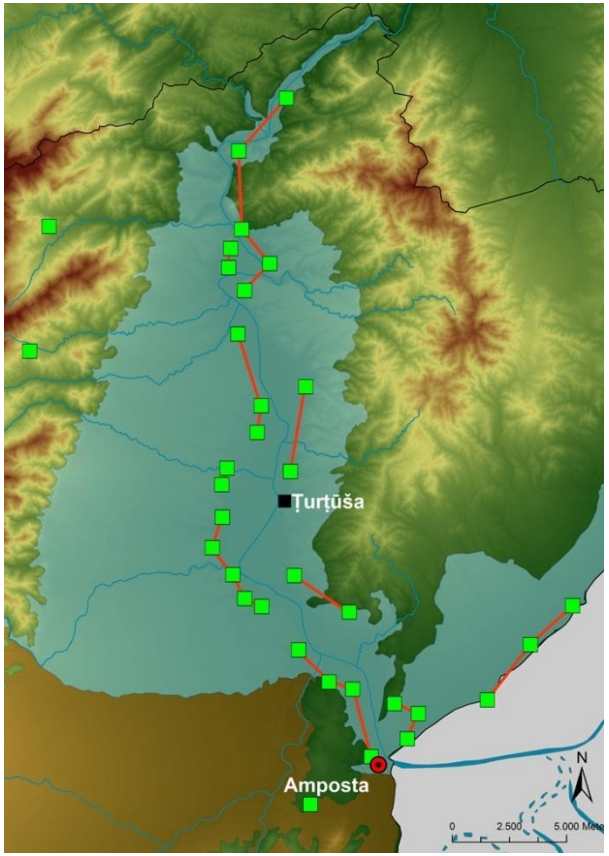
Micro / Macro

Micro: Supuesto Inicial: Espacio Continuo

Macro: Supuesto Inicial: Espacio Discreto

Other case studies: Urban processes in Early Middle Ages





100 spatio-temporal units

We studied the diachronic changes in density and dispersion patterns around an Early Medieval city. Our goal is to understand the urban influence in the Islamisation process.

POSSIBLE SOLUTIONS
Taking spatial heterogeneity into account

TRADITIONAL MODELS
Von Thünen, Weber, Christaller, Hägerstrand

~~HISTORICAL PROCESSES ARE NOT INFLUENCED BY SPATIAL LOCATION~~

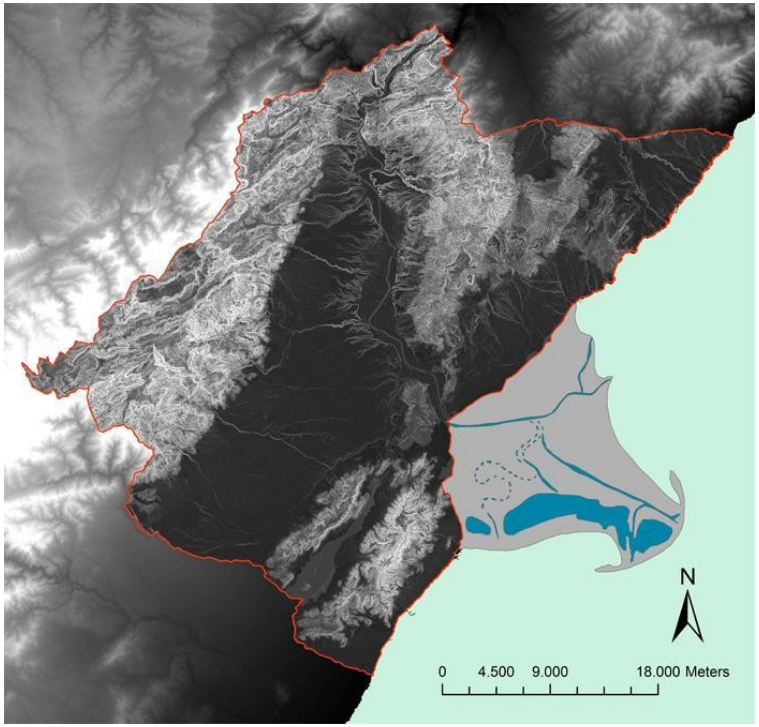
SPATIAL HETEROGENEITY MODEL

THE PROBABILITY OF DIFFERENT ACTIONS VARIED THROUGH TIME AND SPACE

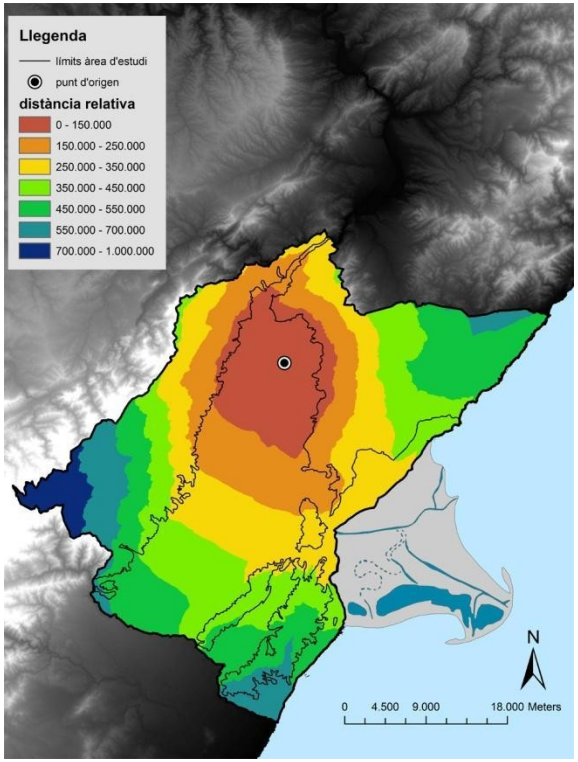
Spatial Heterogeneity & Anisotropic Distances

Spatial Heterogeneity & Anisotropic Distances

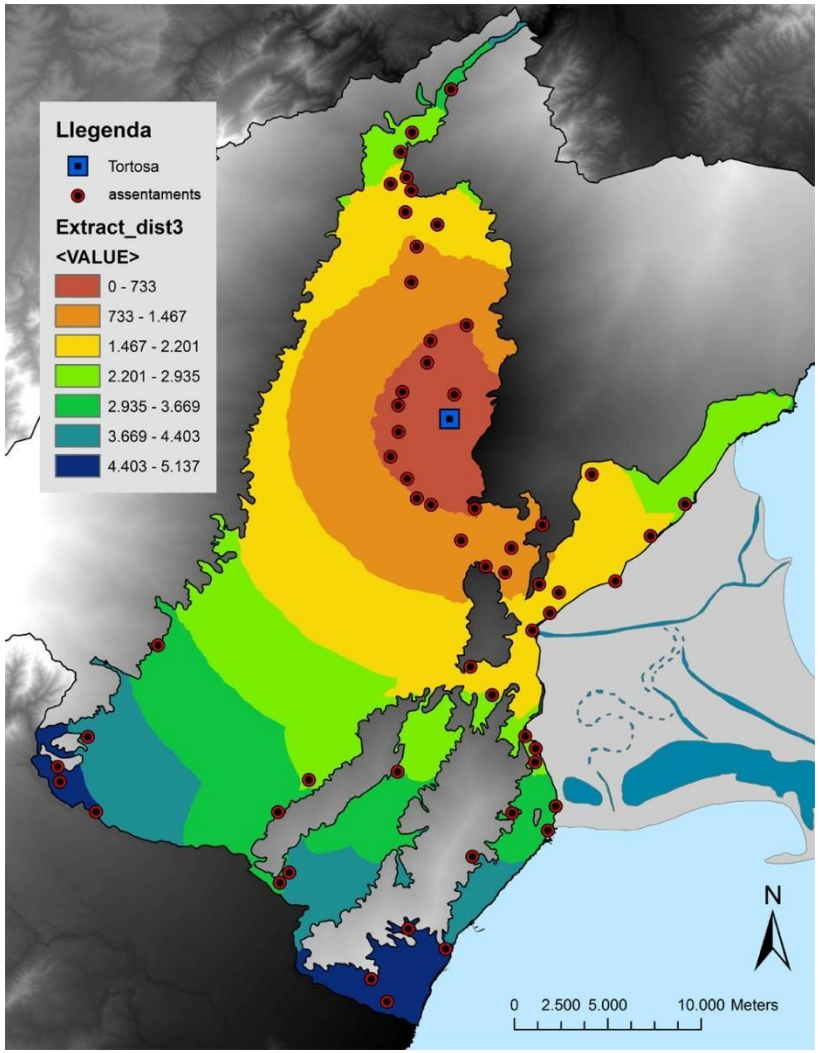
Spatial Heterogeneity → Directional Dependence of Movement → Use of Non-Euclidean Distances



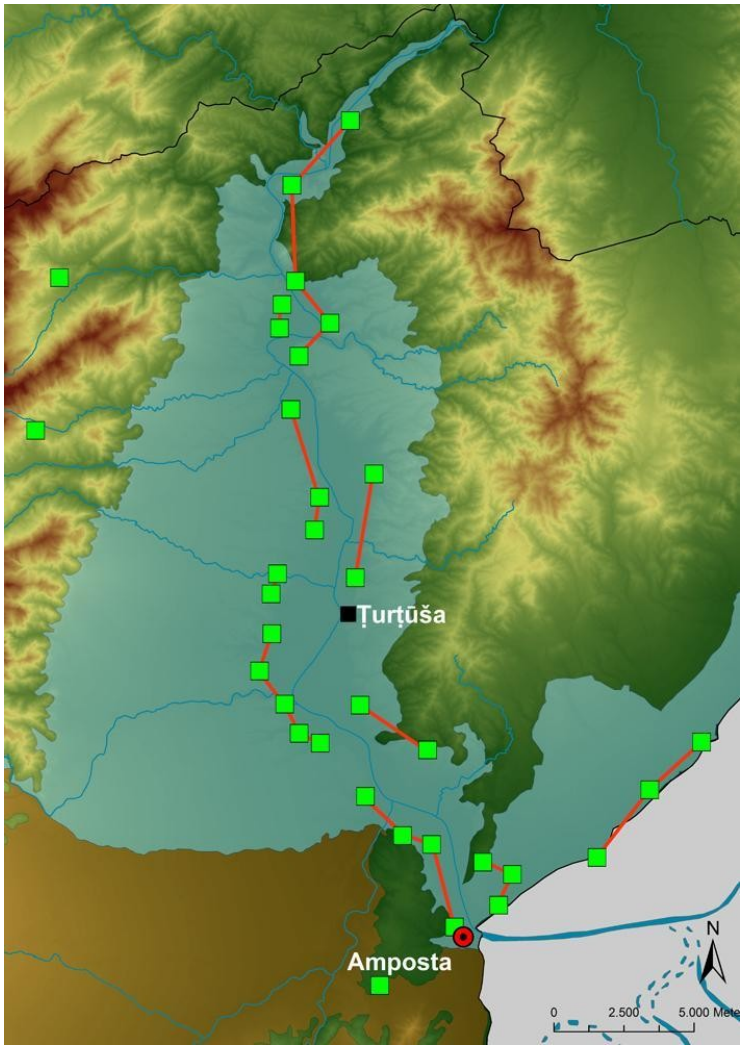
$$\int_0^1 f(\alpha(t))\alpha'(t)dt$$



The Problem



DENSITY (χ^2 TEST)



DISPERSION (LCN)

Why activities occurred where they did?

Why activities occurred where they did?

Because other people did
what they did nearby

Why activities occurred where they did?

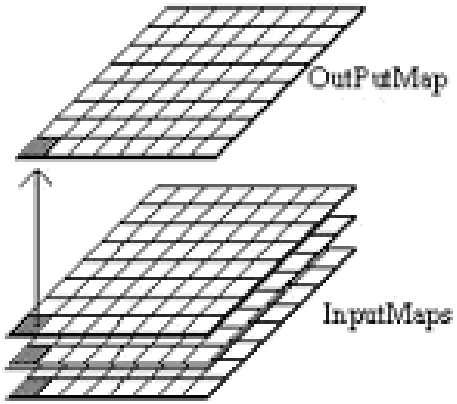
Because other people did
what they did nearby

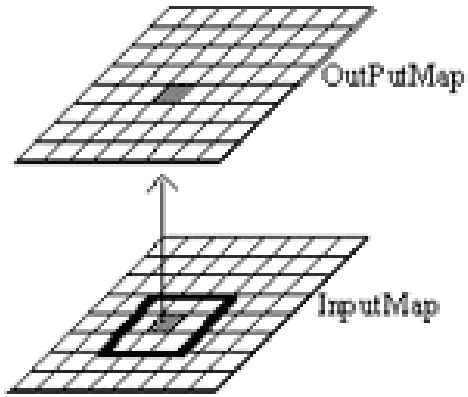
I'M NOT DOING WHAT MY NEIGHBOUR DOES

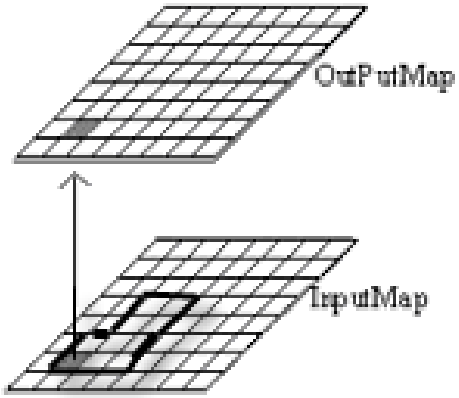
HOWEVER, MY RATIONAL AND IRRATIONAL DECISSIONS
ARE AFFECTED BY THE WAY MY NEIGHBOURS
TAKE RATIONAL AND IRRATIONAL DECISSIONS


Why the fire occurred here?
Because He was there!!
Where occurred the fire?
LDDS
MMX

Spatial Correlation







Correlating Differentiated Spatial Distributions

IANASHUAIA

File Edit Transform Plot Statistics Multivar Model Diversity Time Geomet Strat Cladistics Script

Edit mode | Edit labels | Square mode

	x	y	aves	IND.OSEA	GUANACO	LITICO	G	H	I	J	K
1	3669,94	8590,54	0,00	0,00	0,00	0,00					
2	3669,94	9457,63	0,00	0,00	0,00	0,00					
3	3669,94	10324,71	0,00	0,00	0,00	0,00					
4	3669,94	11191,79	0,00	0,00	0,00	0,00					
5	3669,94	12058,88	0,00	1,00	0,00	0,00					
6	3669,94	12925,96	3,00	1,00	0,00	17,00					
7	3669,94	13793,04	6,00	0,00	0,00	15,00					
8	3669,94	14660,13	0,00	0,00	1,00	10,00					
9	3669,94	15527,21	0,00	0,00	0,00	10,00					
10	3669,94	16394,29	0,00	0,00	0,00	3,00					
11	3669,94	17261,38	0,00	0,00	0,00	3,00					
12	3669,94	18128,46	0,00	0,00	0,00	4,00					
13	4505,81	8590,54	1,00	1,00	0,00	0,00					
14	4505,81	9457,63	0,00	0,00	0,00	0,00					
15	4505,81	10324,71	3,00	0,00	0,00	0,00					
16	4505,81	11191,79	1,00	0,00	0,00	0,00					
17	4505,81	12058,88	11,00	0,00	0,00	0,00					
18	4505,81	12925,96	21,00	0,00	0,00	14,00					
19	4505,81	13793,04	1,00	0,00	0,00	13,00					
20	4505,81	14660,13	3,00	1,00	2,00	25,00					
21	4505,81	15527,21	0,00	0,00	5,00	25,00					
22	4505,81	16394,29	0,00	0,00	2,00	7,00					
23	4505,81	17261,38	2,00	0,00	0,00	2,00					
24	4505,81	18128,46	0,00	0,00	0,00	2,00					
25	5341,69	8590,54	0,00	0,00	0,00	14,00					
26	5341,69	9457,63	0,00	0,00	0,00	28,00					

8	4	2	0	0	1	6	0	0	0	0	1	1	0	0	0	0
7	8	4	0	0	6	4	0	0	0	0	3	2	0	0	0	0
6	23	21	5	0	0	5	1	0	0	0	0	0	0	0	0	1
5	24	11	6	4	2	27	3	0	1	0	11	11	5	0	1	4
4	7	21	10	2	8	14	1	0	9	19	6	0	3	6	10	13
3	29	21	12	4	22	11	0	2	13	13	1	0	5	2	5	0
2	74	31	46	23	28	13	4	5	11	28	6	5	14	10	6	2
1	23	14	15	22	8	13	2	9	6	0	3	4	33	13	0	0
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

8	3	7	23	0	0	12	4	0	0	0	0	4	0	1	0	0
7	5	13	37	2	12	3	10	1	1	1	8	4	0	9	0	0
6	4	2	27	32	24	18	23	0	0	0	1	2	6	13	1	0
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1	0	0	0	1	1	5	3	0	0	0	3	1	0	0	0	0
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

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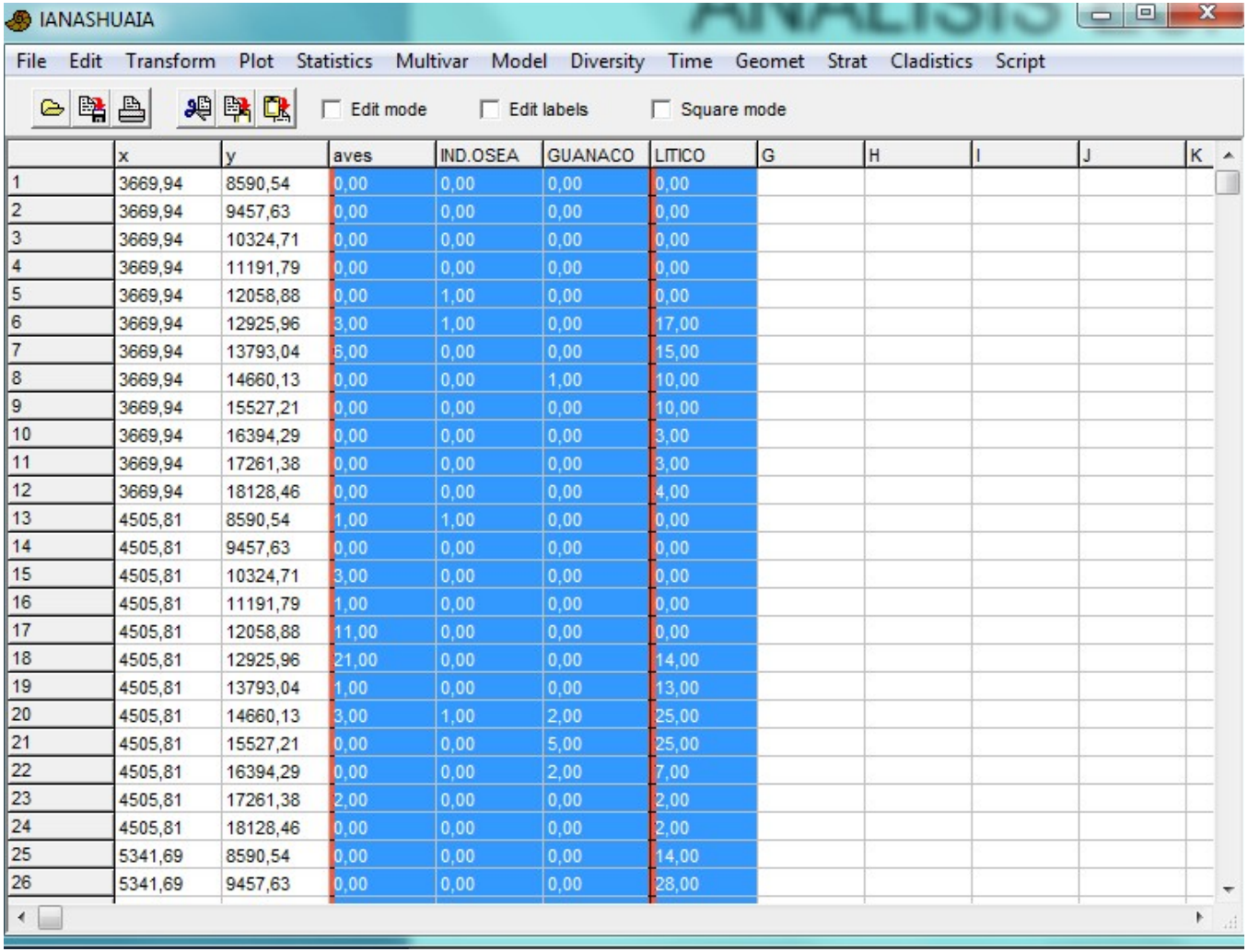
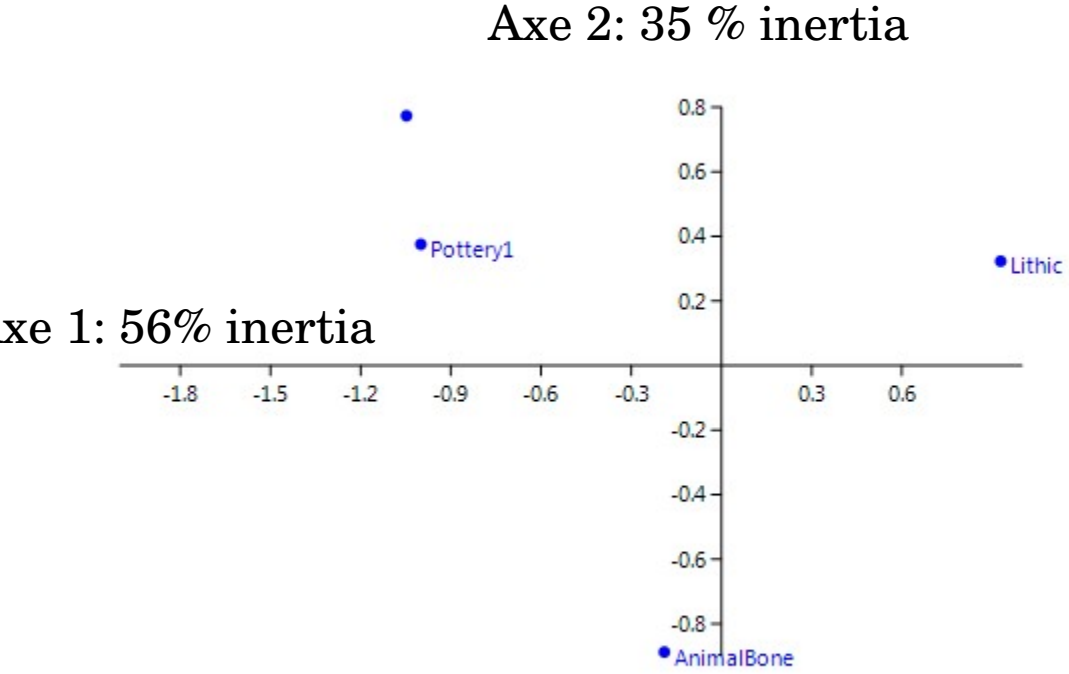
4	9	8	19	29	23	9	4	1	0	0	1	5	0	0	0	0
3	3	6	8	18	9	13	13	8	4	0	0	6	1	0	0	0
2	0	6	2	5	5	15	11	8	8	1	0	0	0	0	0	0
1	0	0	0	1	1	5	3	0	0	0	3	1	0	0	0	0
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Spatially Constrained Correspondence Analysis



	x	y	aves	IND.OSEA	GUANACO	LITICO	G	H	I	J	K
1	3669,94	8590,54	0,00	0,00	0,00	0,00					
2	3669,94	9457,63	0,00	0,00	0,00	0,00					
3	3669,94	10324,71	0,00	0,00	0,00	0,00					
4	3669,94	11191,79	0,00	0,00	0,00	0,00					
5	3669,94	12058,88	0,00	1,00	0,00	0,00					
6	3669,94	12925,96	3,00	1,00	0,00	17,00					
7	3669,94	13793,04	6,00	0,00	0,00	15,00					
8	3669,94	14660,13	0,00	0,00	1,00	10,00					
9	3669,94	15527,21	0,00	0,00	0,00	10,00					
10	3669,94	16394,29	0,00	0,00	0,00	3,00					
11	3669,94	17261,38	0,00	0,00	0,00	3,00					
12	3669,94	18128,46	0,00	0,00	0,00	4,00					
13	4505,81	8590,54	1,00	1,00	0,00	0,00					
14	4505,81	9457,63	0,00	0,00	0,00	0,00					
15	4505,81	10324,71	3,00	0,00	0,00	0,00					
16	4505,81	11191,79	1,00	0,00	0,00	0,00					
17	4505,81	12058,88	11,00	0,00	0,00	0,00					
18	4505,81	12925,96	21,00	0,00	0,00	14,00					
19	4505,81	13793,04	1,00	0,00	0,00	13,00					
20	4505,81	14660,13	3,00	1,00	2,00	25,00					
21	4505,81	15527,21	0,00	0,00	5,00	25,00					
22	4505,81	16394,29	0,00	0,00	2,00	7,00					
23	4505,81	17261,38	2,00	0,00	0,00	2,00					
24	4505,81	18128,46	0,00	0,00	0,00	2,00					
25	5341,69	8590,54	0,00	0,00	0,00	14,00					
26	5341,69	9457,63	0,00	0,00	0,00	28,00					

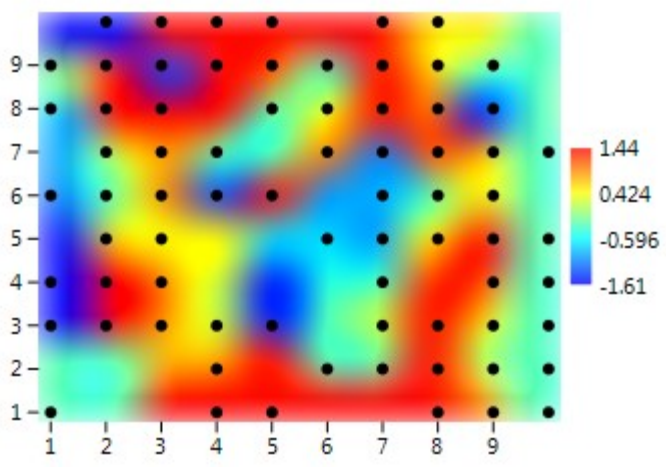
Spatially Constrained Correspondence Analysis



	Axis 1	Axis 2	Axis 3
1	-0.293896	-2.20104	0.76671
3	-1.60228	1.67154	2.4952
4	-1.54696	0.931213	-6.47682
6	-1.08506	-0.0227083	-0.709457
8	-0.906616	-0.535651	-0.710364
9	-0.0466913	-1.77221	0.625382
13	1.43653	0.800765	-0.222589
14	1.43653	0.800765	-0.222589
15	0.571319	-0.700135	0.27206
16	-0.124104	0.22262	-0.825263
17	0.200513	-1.34338	0.484053

Spatially Constrained Correspondence Analysis

	x	Y	Axis 1
1	1	1	-0.293896
3	1	3	-1.60228
4	1	4	-1.54696
6	1	6	-1.08506
8	1	8	-0.906616
9	1	9	-0.0466913
13	2	3	1.43653
14	2	4	1.43653
15	2	5	0.571319
16	2	6	-0.124104
17	2	7	0.200513
18	2	8	1.43653
19	2	9	1.43653
20	2	10	-1.5654
23	3	3	0.859724
24	3	4	0.859724
25	3	5	0.446013
26	3	6	1.00393
27	3	7	0.859724
28	3	8	1.43653
29	3	9	-1.31199
30	3	10	1.43653



In red locations where Pottery 1 and 2 is abundant

In blue locations where Pottery 1 and 2 is scarce

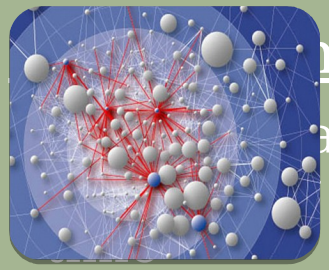
Space-Temporal Analysis.
An example

SPACE-TEMPORAL ANALYSIS OF RADIOCARBON EVIDENCE AND ASSOCIATED ARCHAEOLOGICAL RECORD: FROM DANUBE TO EBRO RIVERS AND FROM BRONZE TO IRON AGES

Giacomo CAPUZZO, J.A. BARCELÓ

Department of Prehistory, Autonomous University of Barcelona

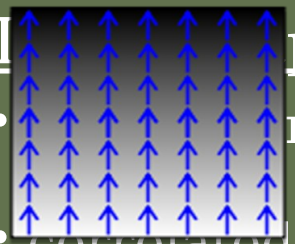
Expansive phenomena



natics

al system such that every point of the space has a distinctive behavior through

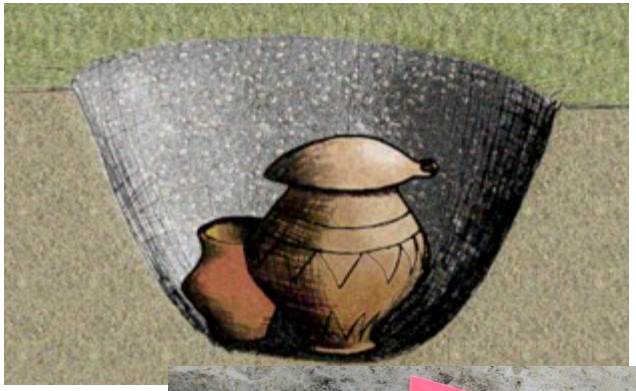
e in volume resulting from an increase in re



phy

- n which a gradient of a scalar field can be
- correlated with the notion of directivity

The historical problem:



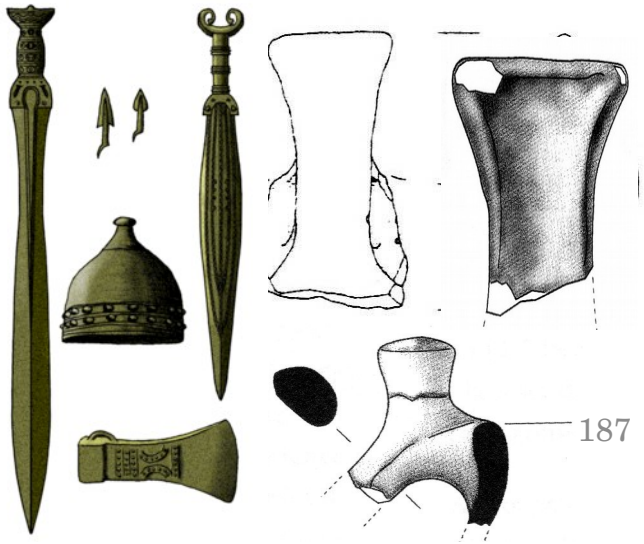
<u>"Urnfield culture"</u> (1300-650 BC). A process of Cultural Standardization

Around 1100 BC Europe was characterized by a number of quite distinct regional traditions rooted in or influenced in the Urnfield tradition of shared burial rituals and religion.

The diffusion of cremation burials at the end of the Bronze Age has been traditionally seen as an expansion from the Danube-Carpathian area toward northern and western territories.

The possibility of expansive processes has been traditionally detected also for other variables, like specific pottery typologies.

<u>How can we quantify such phenomena?</u>

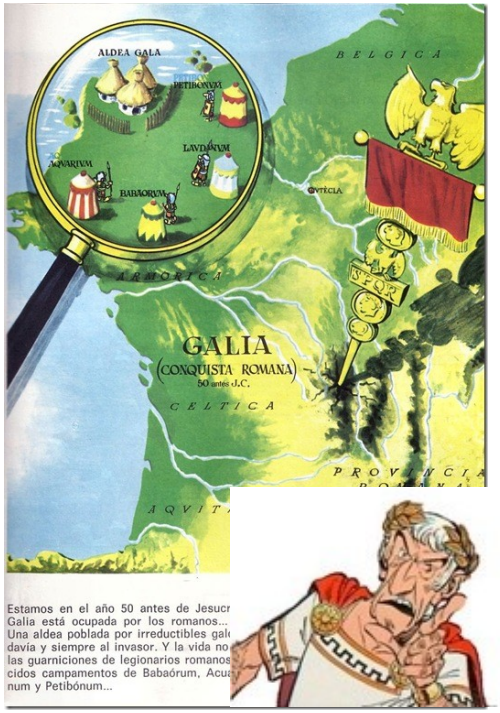


Expansive phenomena: European Bronze Age as a case study

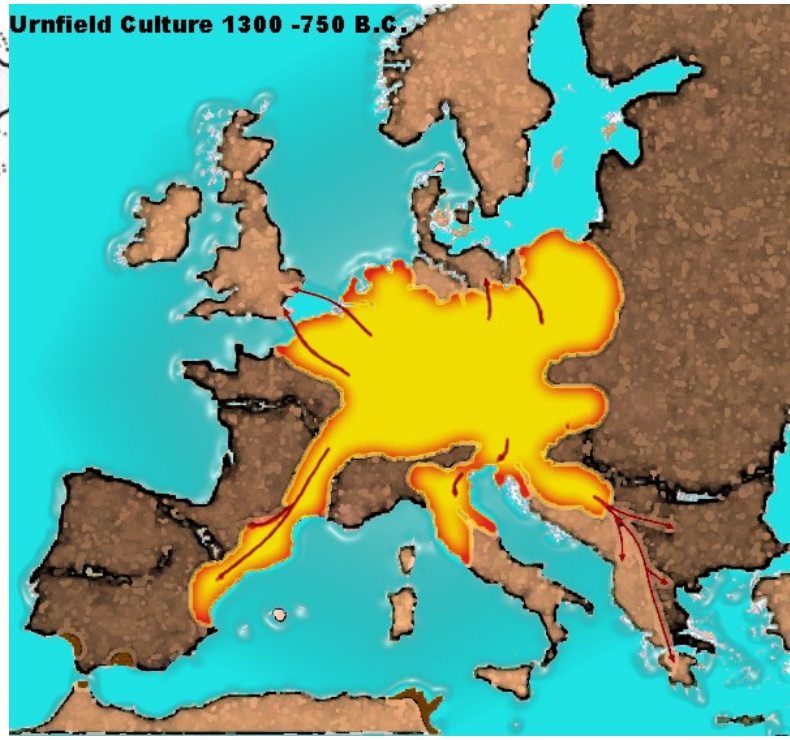
- **Population Substitution**: Invasion, migration, colonization (Wave of Advance)

- **Adoption of a "foreign" idea** (Cultural Transmission, acculturation). "Knowledge" or "behavior" travel even in the case people do not move.

- **Social Influence Theory** (adoption of innovation)

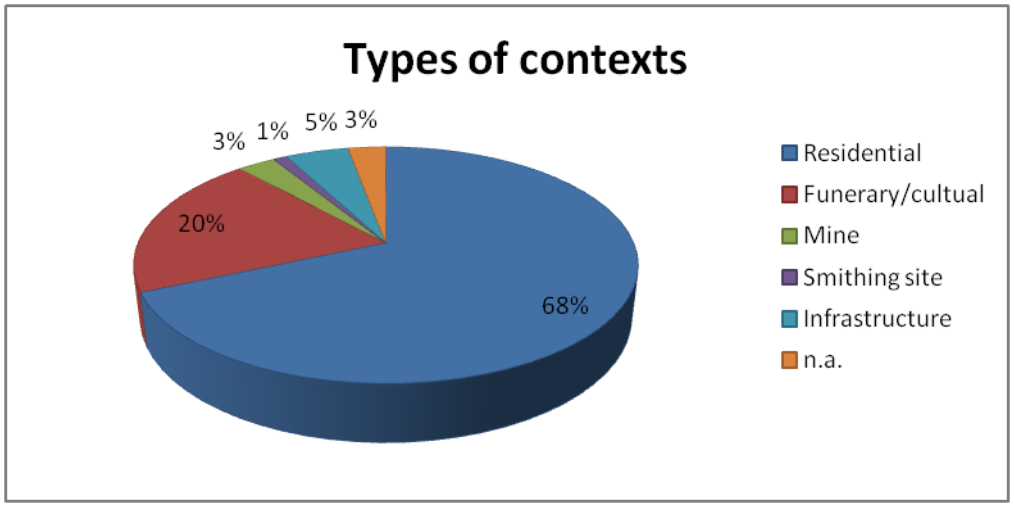


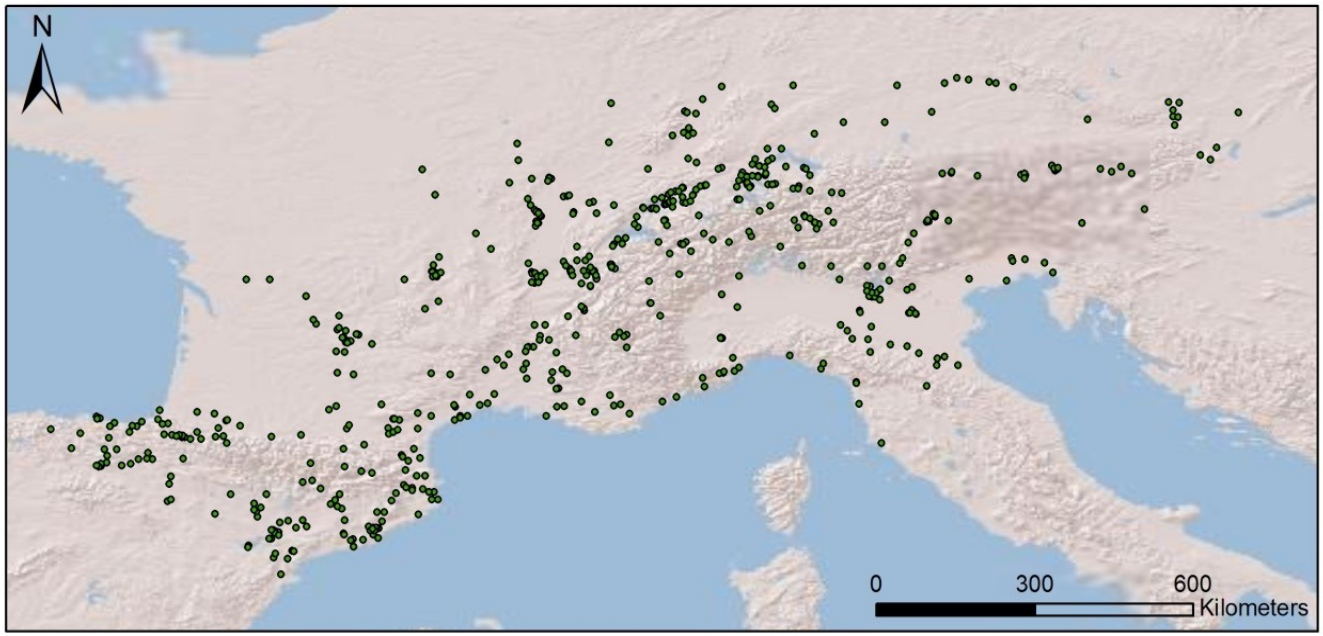
FROM EAST TO WEST AND THE OTHER WAY AROUND



EUBAR: ^{14}C-dated archaeological contexts

It includes more than 1700 ^{14}C dates with information about a large variety of associated archaeological contexts from the Danube to the Ebro rivers and from the Bronze to the Iron Ages.

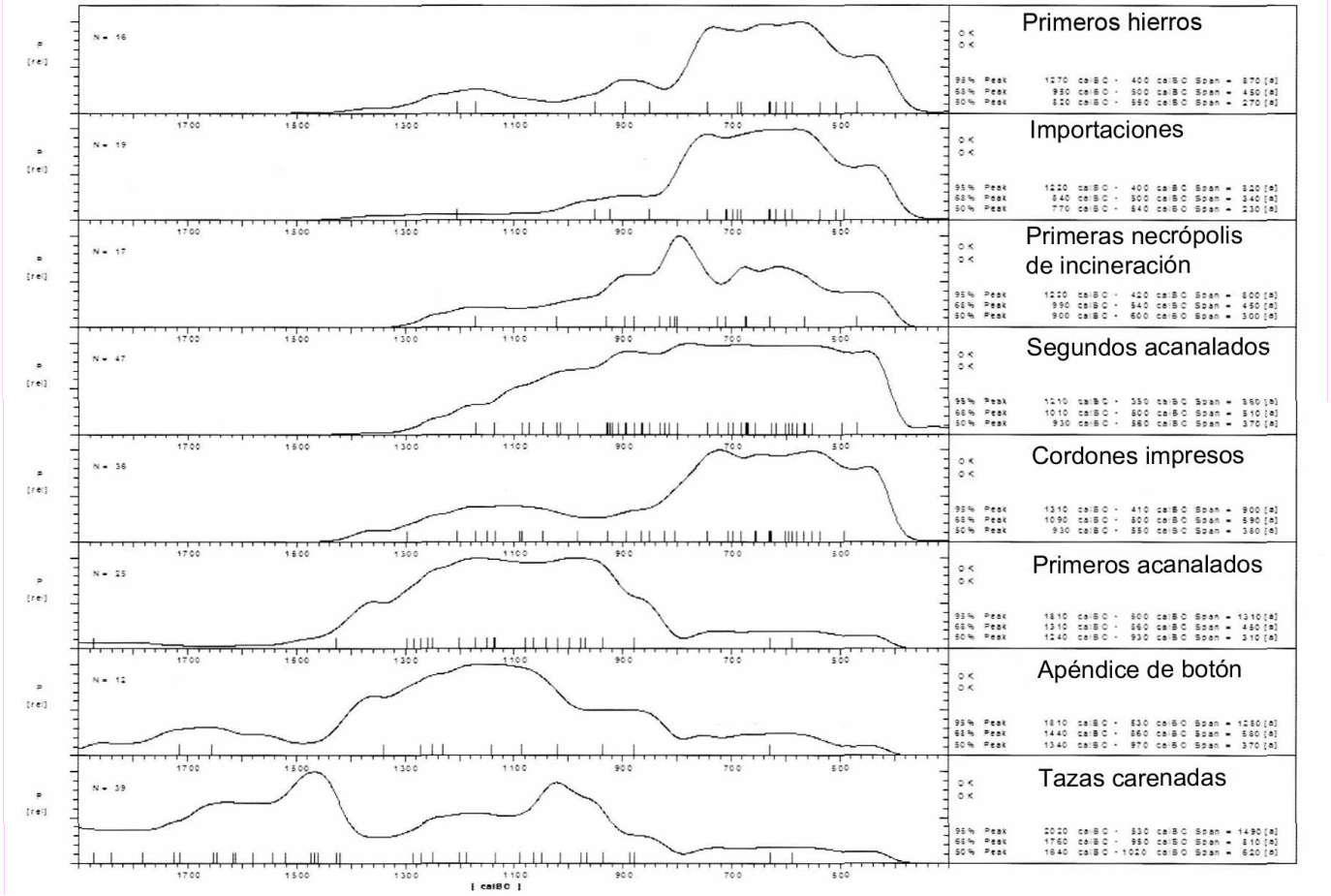




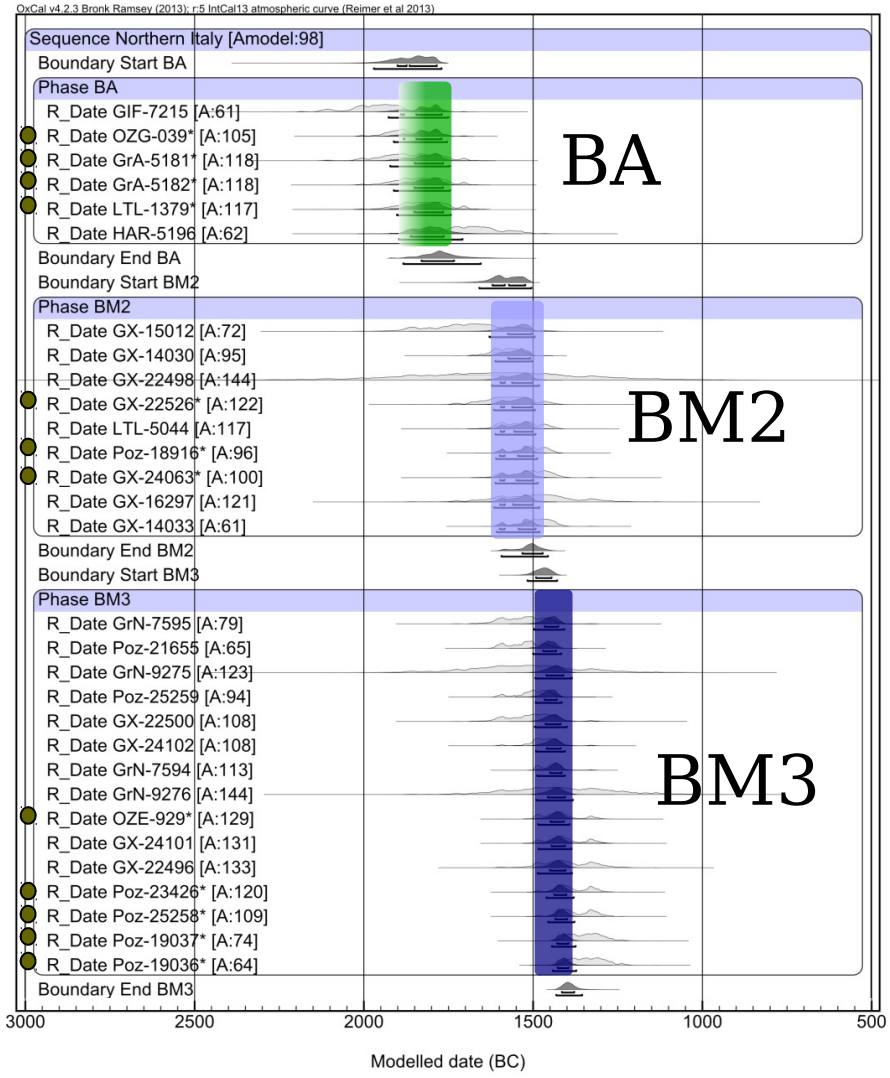
The traditional conventional chronology

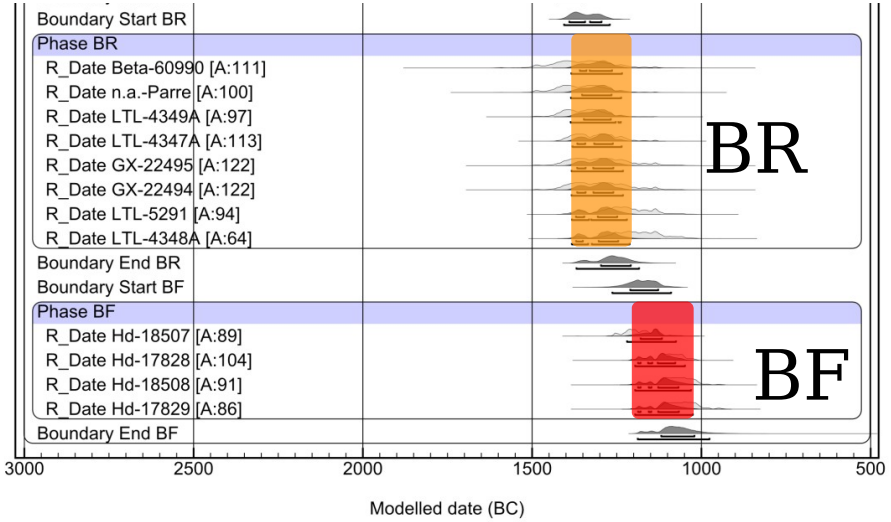
Years BC	N of the Alps	S France	N Italy	N-E Iberian Peninsula
750	HaC	Fer		Hierro
800	HaB2/3	BF3b	Fe	BFb
850				
900				
950	HaB1	BF3a	BF3	
1000				
1050	HaA2	BF2b	BF2	BFa
1100			BF1	
1150	HaA1		BR2	
1200	BzD	BF2a		
1250			BR1	
1300		BF1		
1350	BzC2	BM2/(3)	BM3	BM
1400				
1450	BzC1			
1500	BzB	BM1	BM2	
1550				
1600	BzA2		BM1	
1650				
1700		BA3	BA2	
1750				
1800				
1850			BA1	BA
1900		BA2		
1950	BzA1			
2000		BA1		

COMPARACI N DE LAS DATACIONES DE DIFERENTES CONTEXTOS ARQUEOL GICOS DE CATALU A (Se han eliminado las dataciones con desviaciones t picas superiores a 80 aæos) (Fuente: BARCEL J. A. 2007-08, La seq Łncia crono-cultural de la prehistoria catalana. Analisi estad stica de les datacions radiomŁtriques. *Cypsela* 17:65-88.)

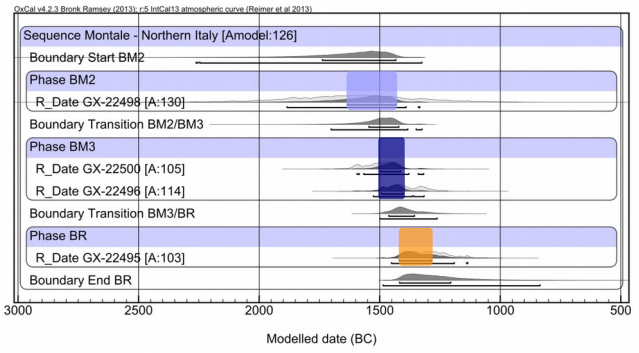


Sequential model for archaeological contexts located in Northern Italy (A_{model}=98.4)

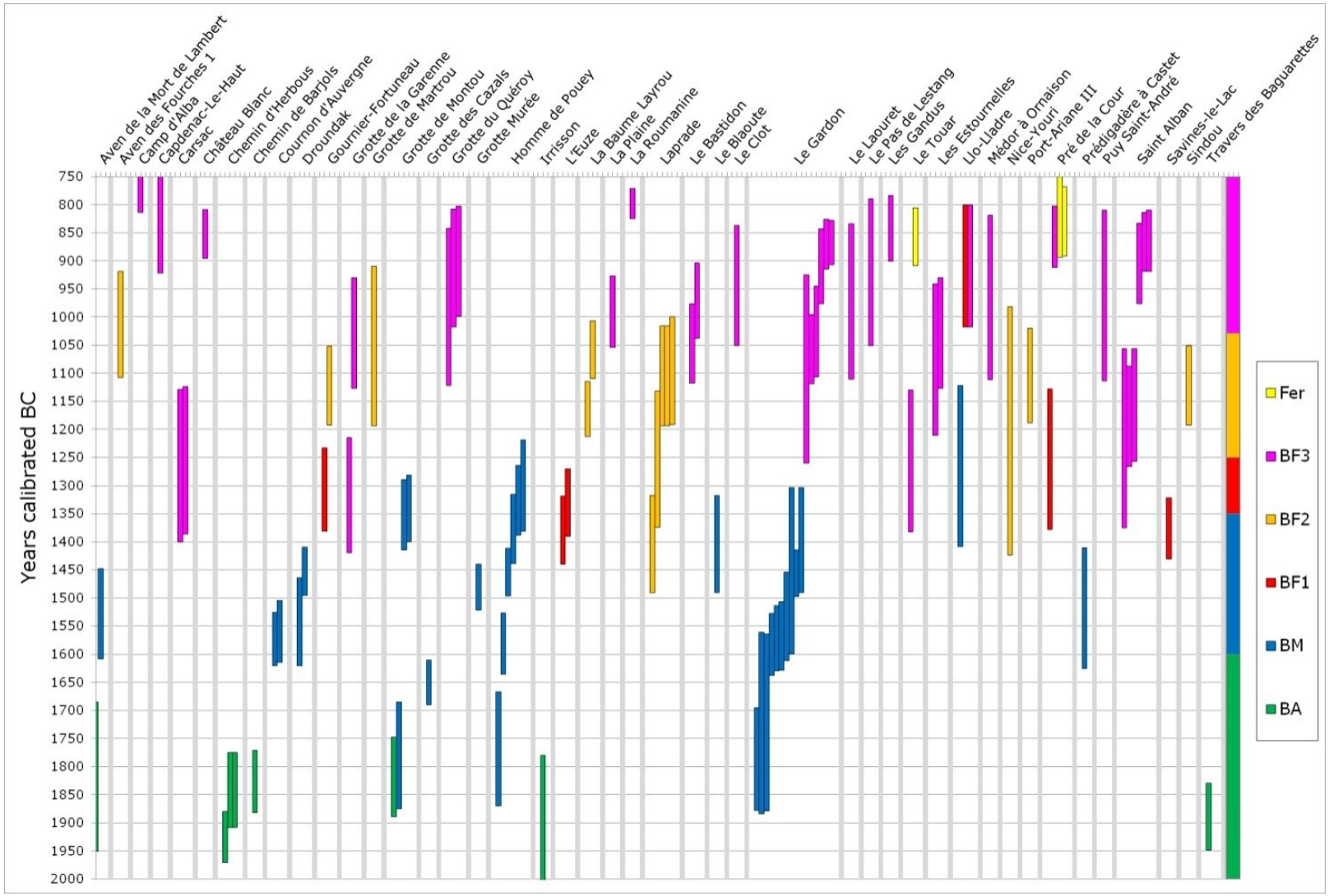




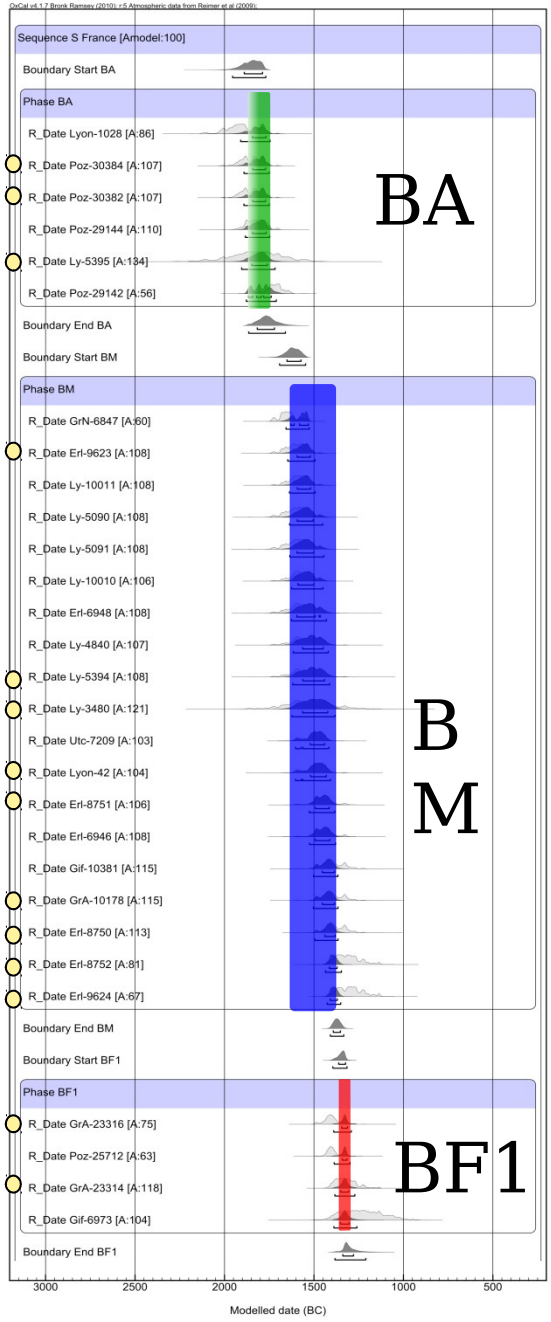
Contiguous model for the settlement of Montale located in Northern Italy (A_{model}=126.1)

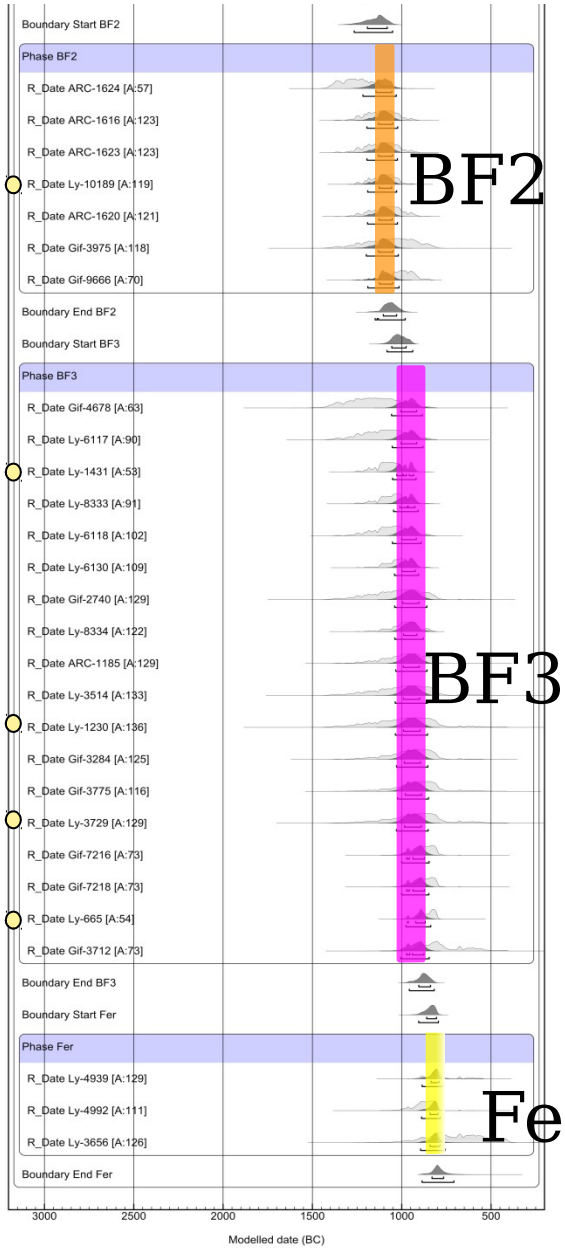


Radiocarbon dates (1σ) from reliable archaeological contexts located in Southern France

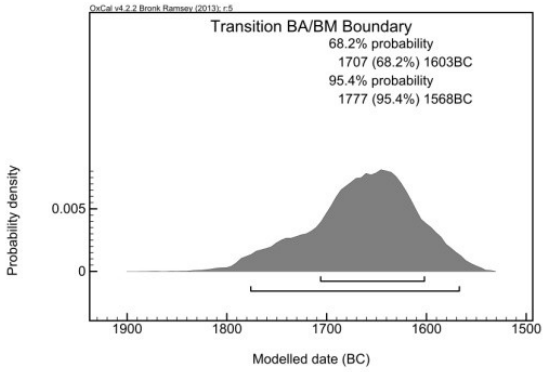


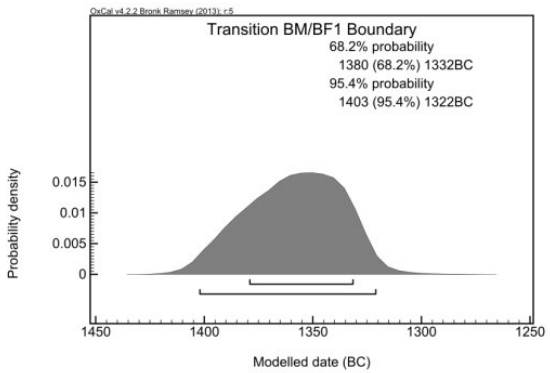
LA CRONOLOG˝A DE LA EDAD DEL BRONCE EN EL SUR DE FRANCIA

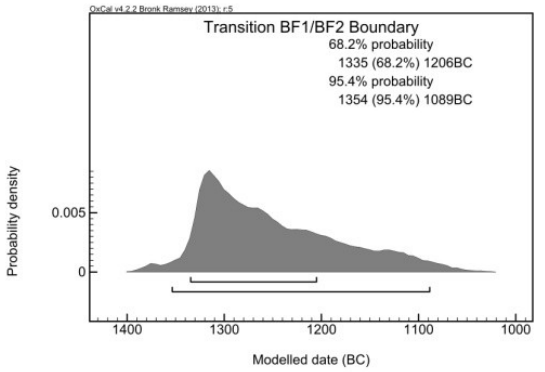


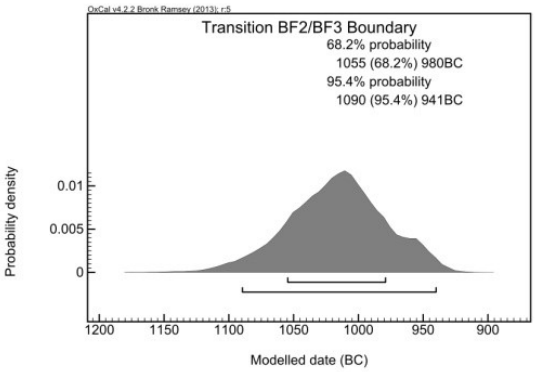


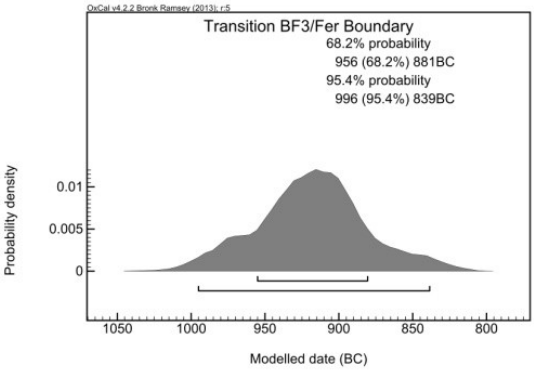
Transition boundaries of the contiguous model for archaeological contexts located in Southern France (A_{model}=145.7)





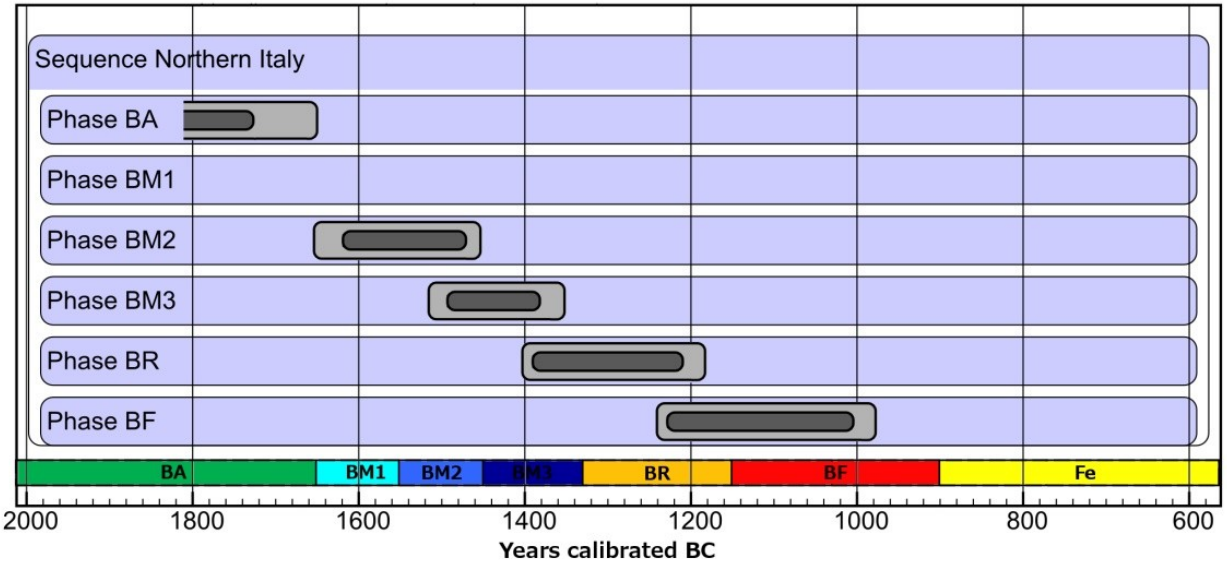




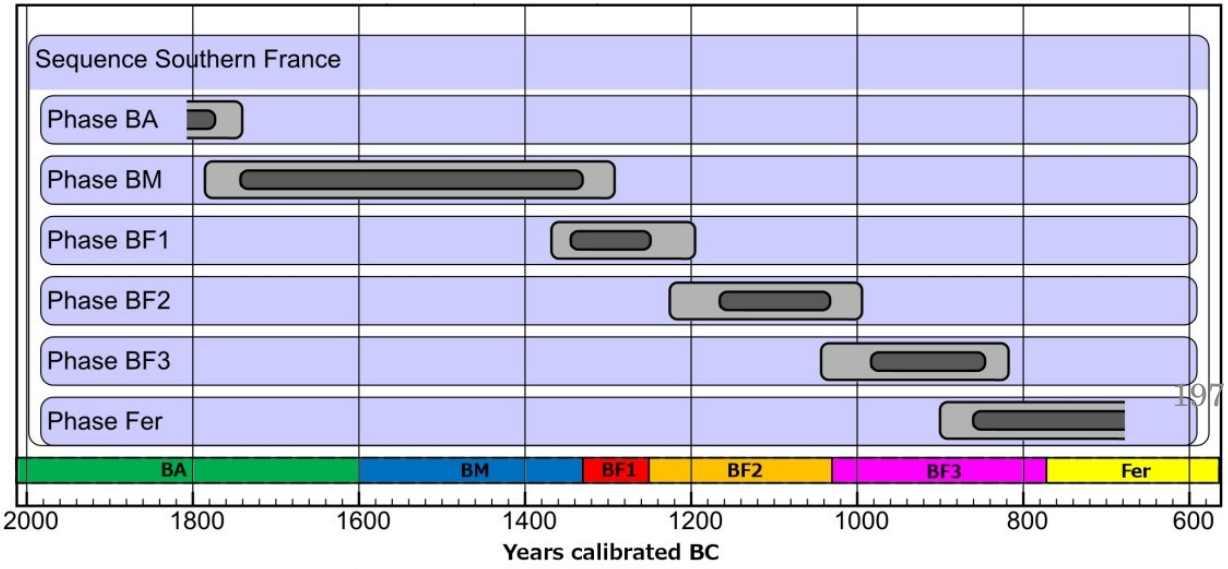


RESULTS OF THE BAYESIAN MODELING FOR NORTHERN ITALY AND SOUTHERN FRANCE. Only the analyzed sub phases have been represented. The conventional chronology is shown above the x-axis.

NORTHERN ITALY



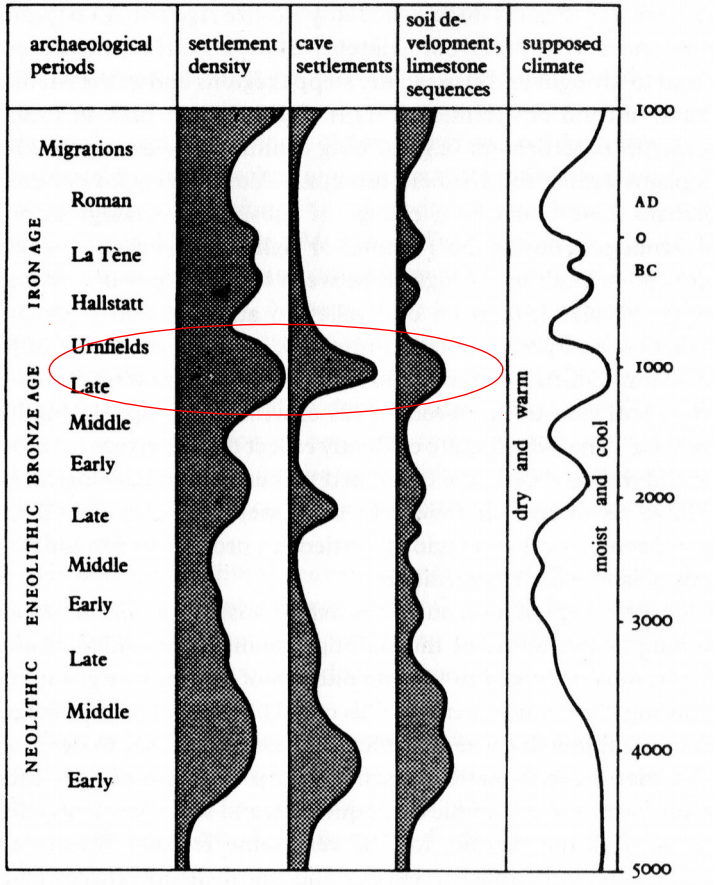
SOUTHERN FRANCE



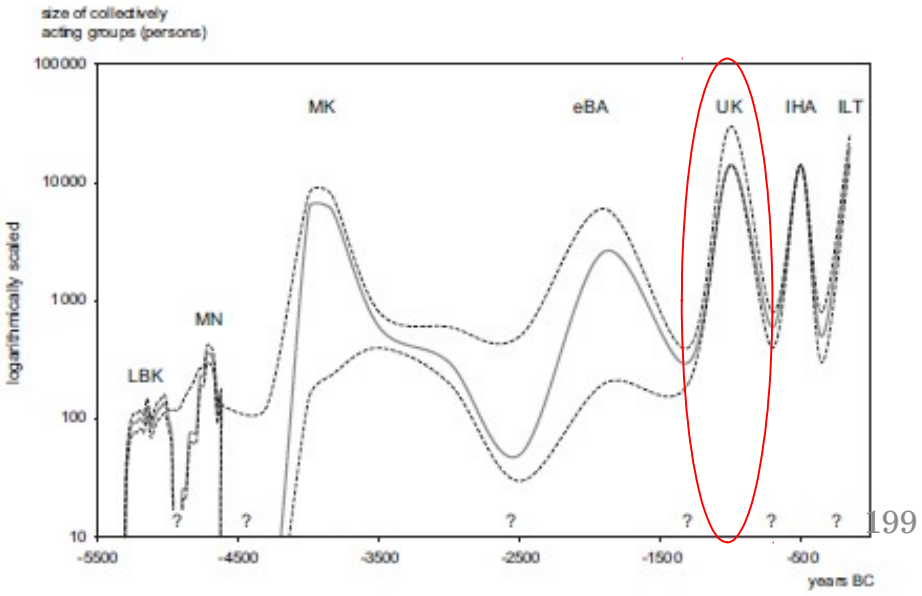
INFERRING POPULATION GROWTH FROM ^{14}C DATA

THE STUDY OF POPULATION TRENDS IN THE BRONZE AGE AND IN THE IRON AGE TRANSITION

Kristiansen (1998b) suggested that the Urnfield period was one on the most densely populated phase in the Prehistory characterized by an enhance of population size in a large part of Europe, mainly in the period 1100/1000 BC.



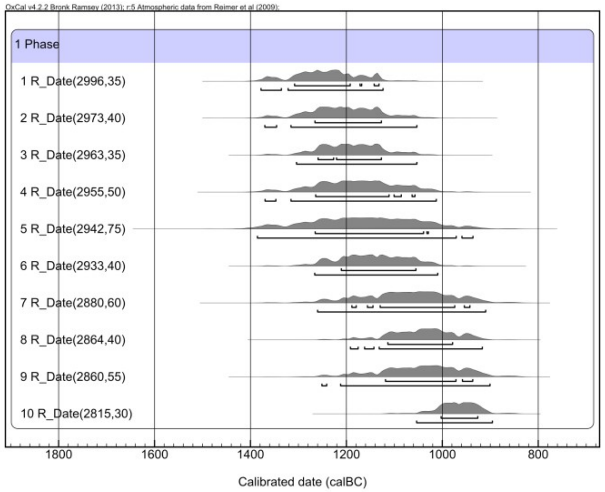
For the Bronze Age Zimmerman (2009, 2012) argued population densities in Central Europe between 0.6 and 1.8 persons per 100 km^2

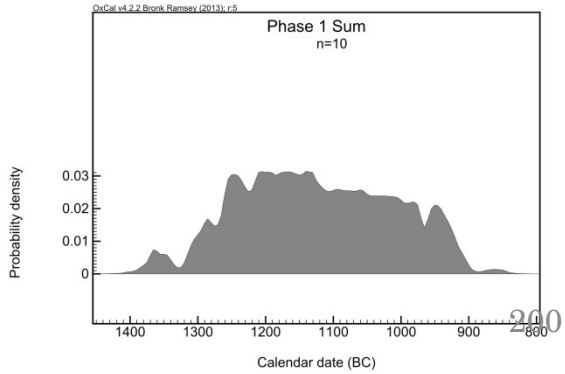


INFERRING DEMOGRAPHIC CHANGES FROM THE RADIOCARBON RECORD

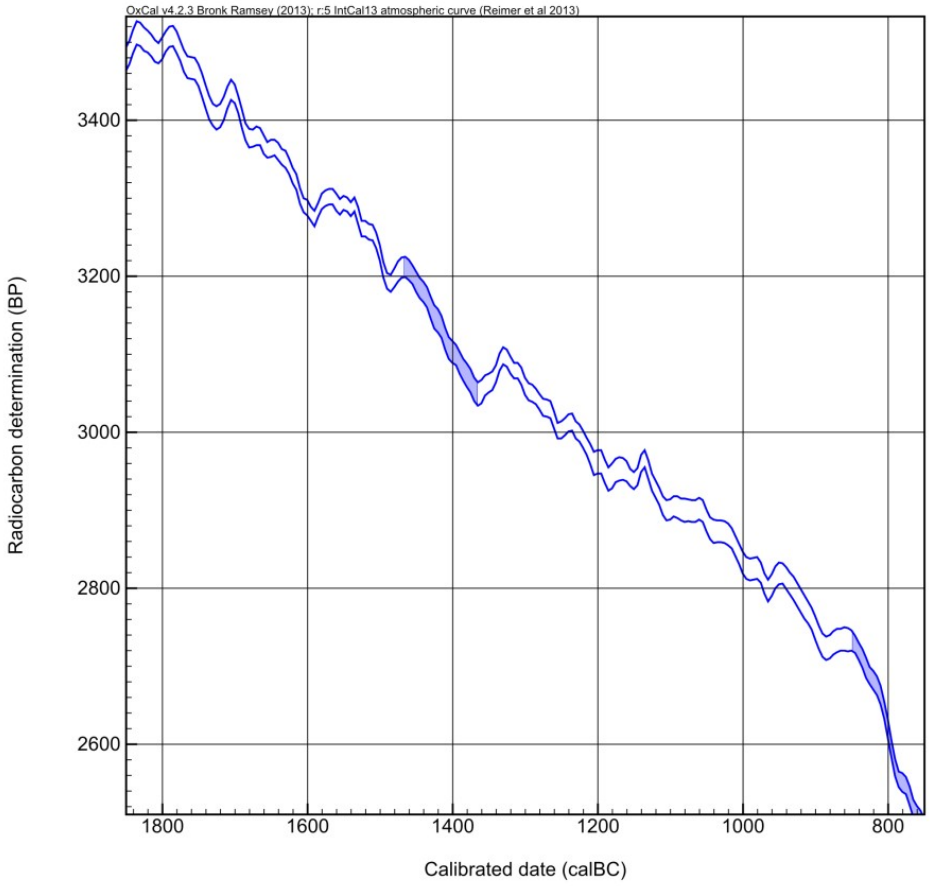
^{14}C DATE (ISOTOPIC EVENT)	EVIDENCE OF AN INDIVIDUAL ACTION
DATASET OF ^{14}C DATES (ARCHAEOLOGICAL EVENT)	EVIDENCE OF A COLLECTIVE ACTION

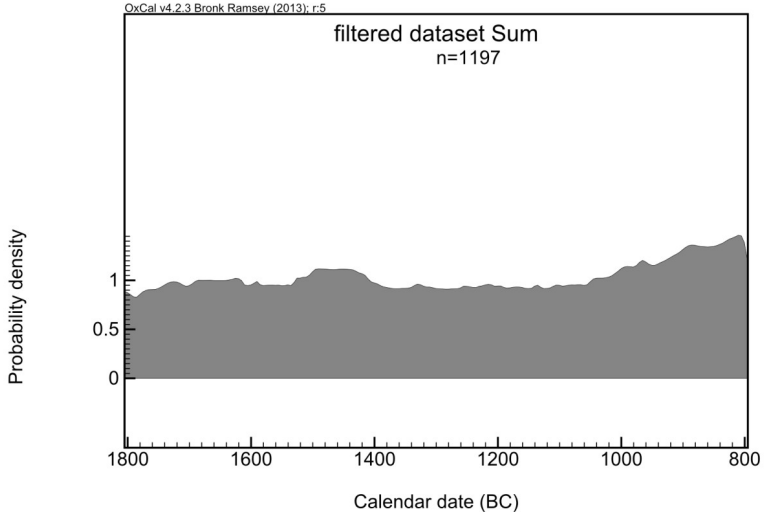
Summing a group of radiocarbon dates we can infer demographic changes in a space-time unit. The most used method is the Summed Calibrated Probability Distribution (SCPD).

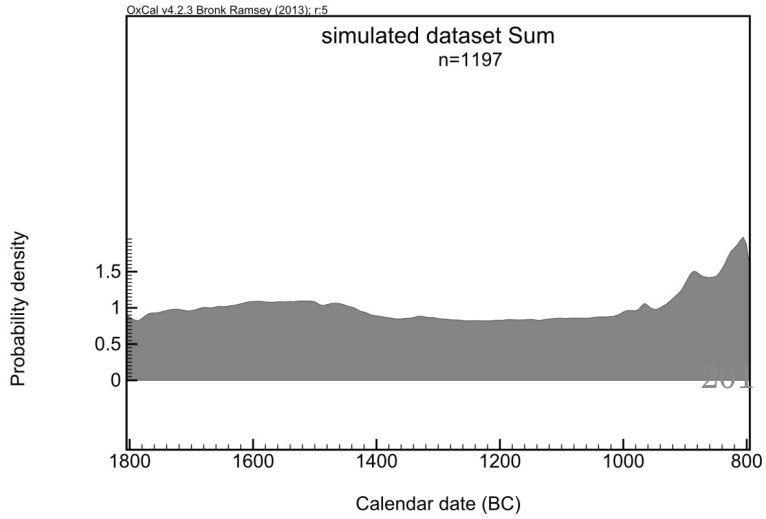




POPULATION STATIONARITY BETWEEN 1800 AND 800 BC ON A MACRO SCALE



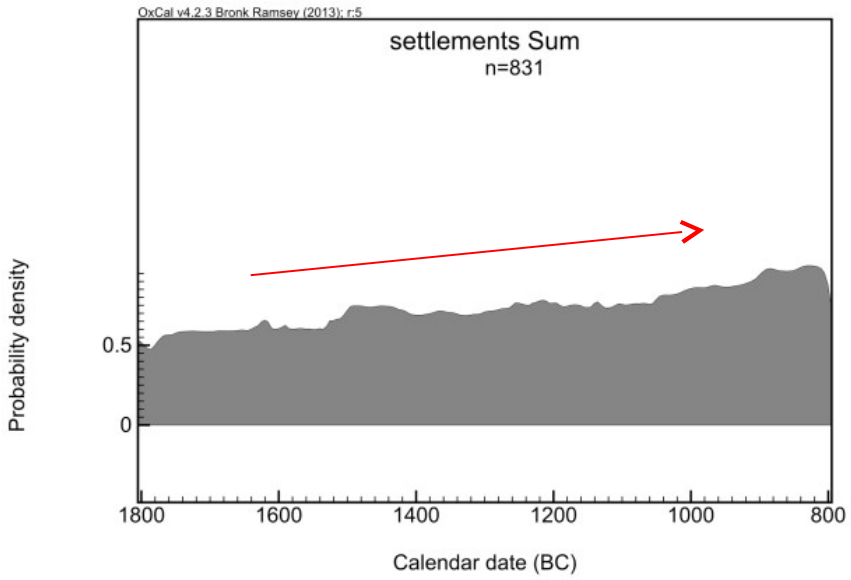




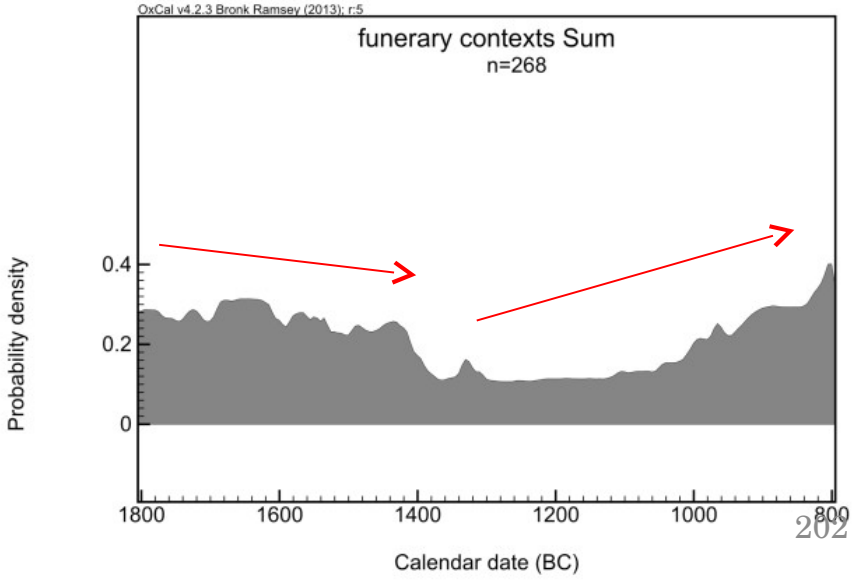
POPULATION STATIONARITY BETWEEN 1800 AND 800 BC ON A MACRO SCALE

Since we do not want to count twice the same demographic signal we have divided between:

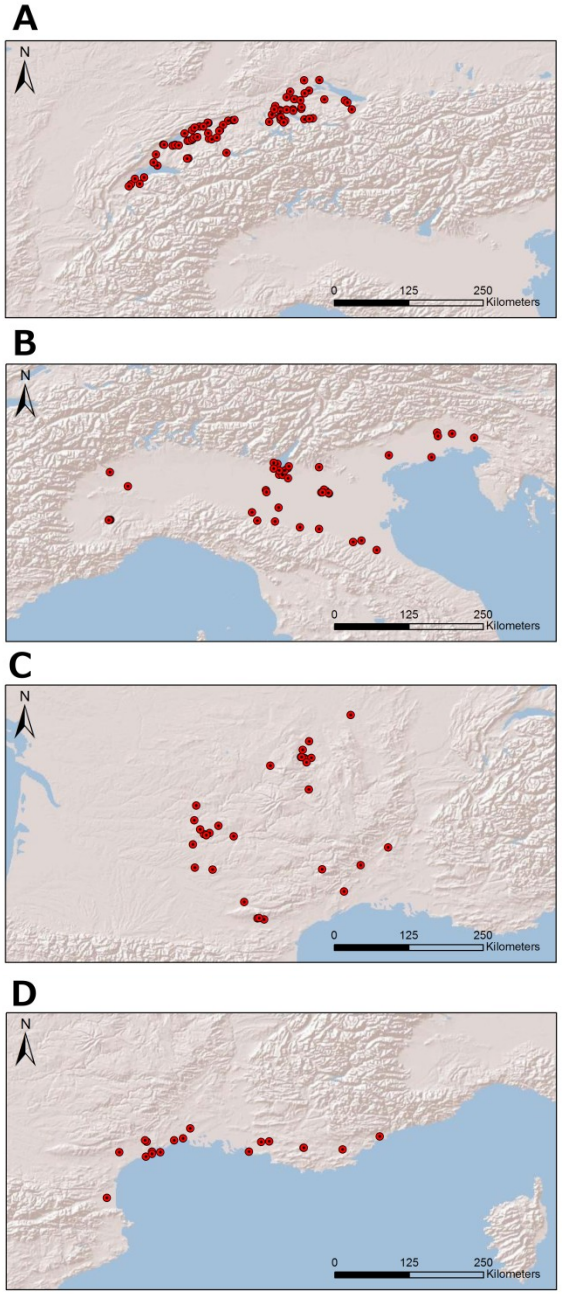
Residential areas

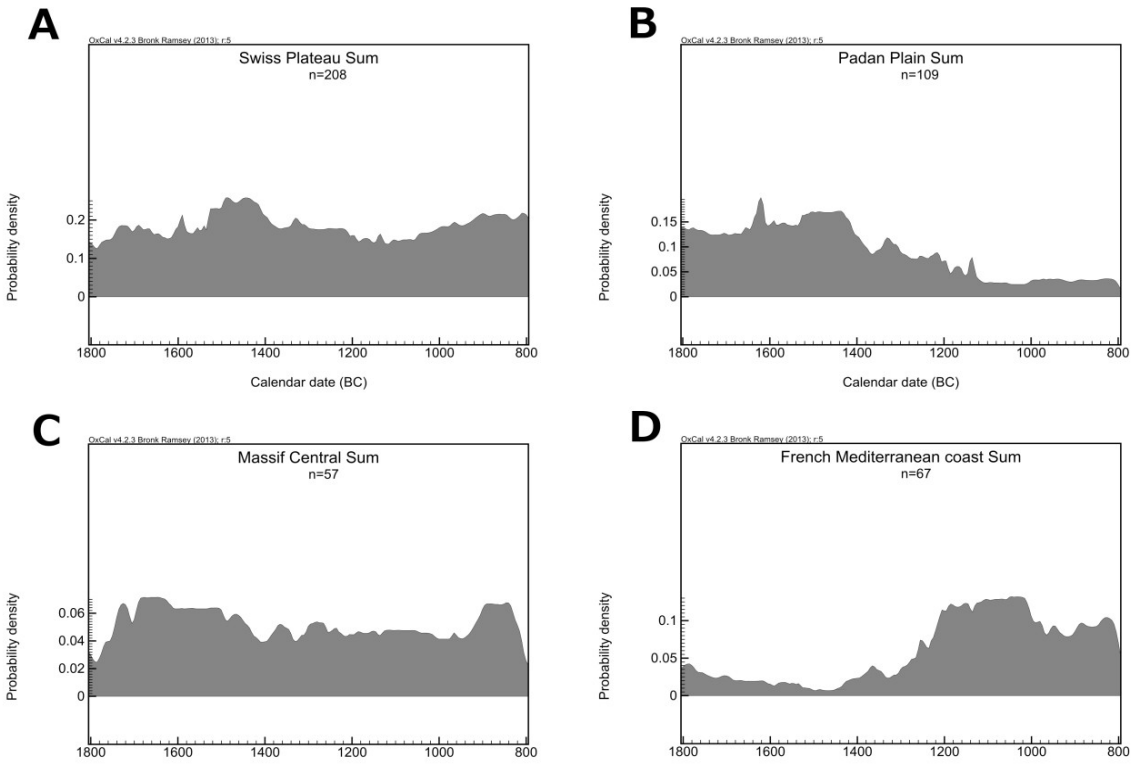


Funerary contexts



DIFFERENCES IN THE TEMPORAL DISTRIBUTION OF COLLECTED DATA BETWEEN 1800 AND 800 BC ON A REGIONAL SCALE





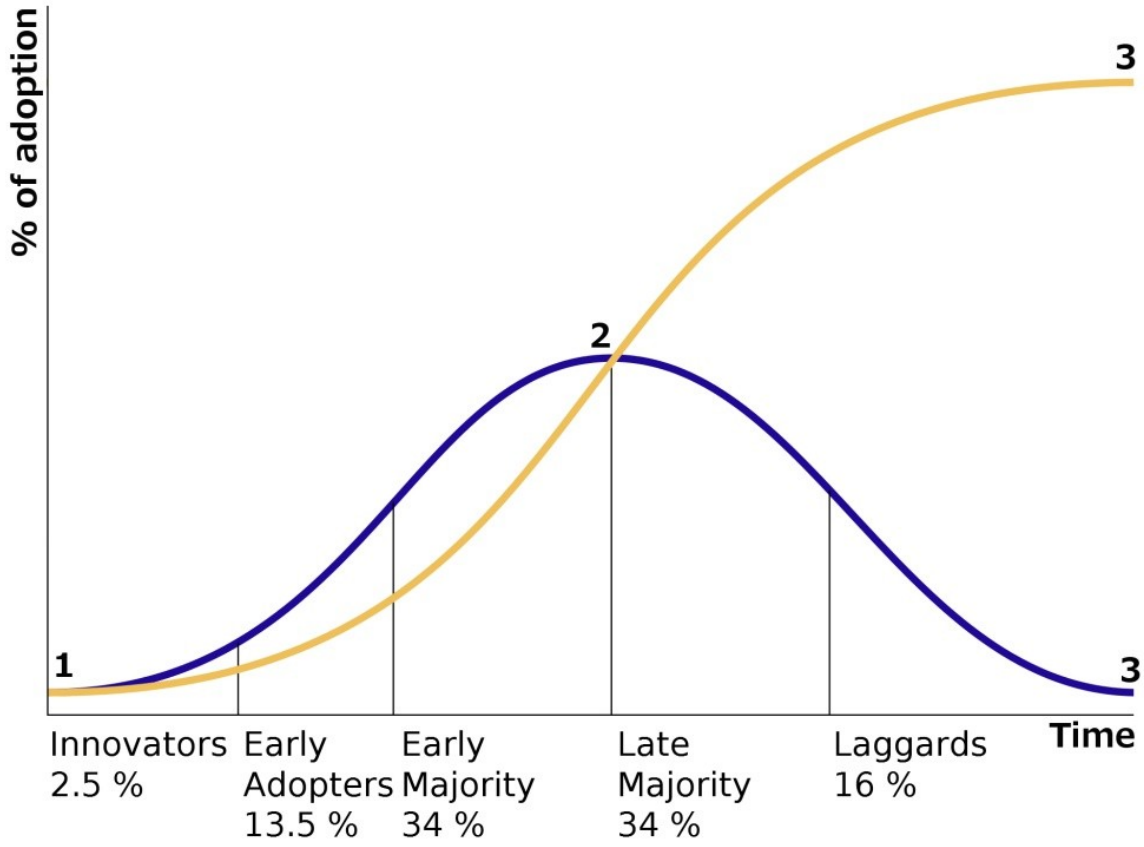
Archaeological sites included in the regional SCPDs. The Swiss Plateau (A), the Padan Plain (B), the Massif Central (C) and the French Mediterranean coast (D).

GROWTH, DIFFUSION AND THE ADOPTION OF INNOVATIONS ACROSS TIME

SOCIAL THEORY: CULTURAL TRANSMISSION

- *The Innovation* → Cremation burials and new pottery an metallic typologies
- *Interaction Channels* → Mediums by which information is transmitted to or within a social system
- *Time* → 
- *Space* → 
- *The Social System* → "a set of interrelated units that are engaged in joint problem-solving to accomplish a common goal" (Rogers 2003)

THEORETICAL REMARKS: The S-shaped curve

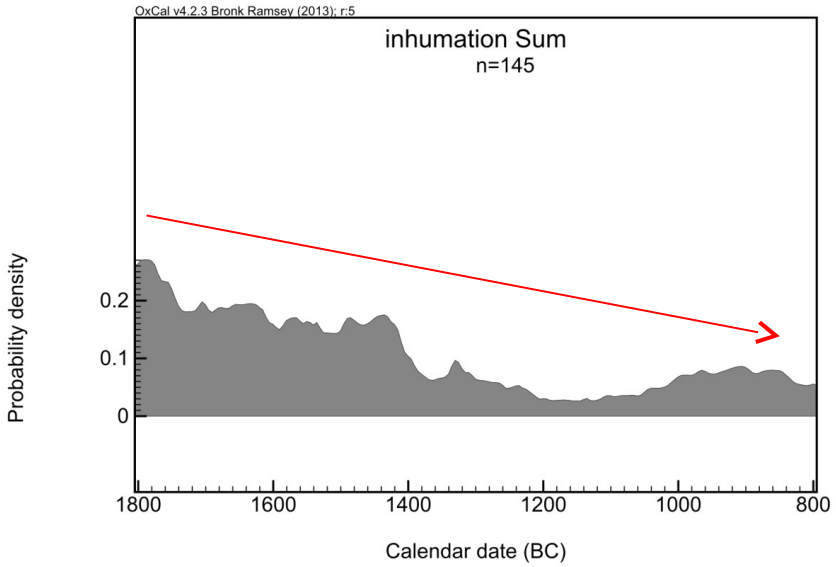


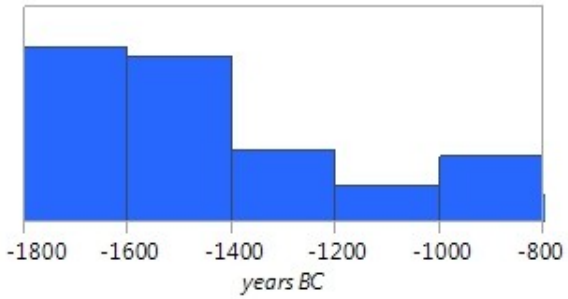
The diffusion of innovation according to Rogers (2003). The normal distribution is in blue and the cumulative frequency distribution is in yellow.

SCPDs AND HISTOGRAMS OF MEDIANS OF FUNERARY CONTEXTS INCLUDED IN THE EUBAR DATABASE

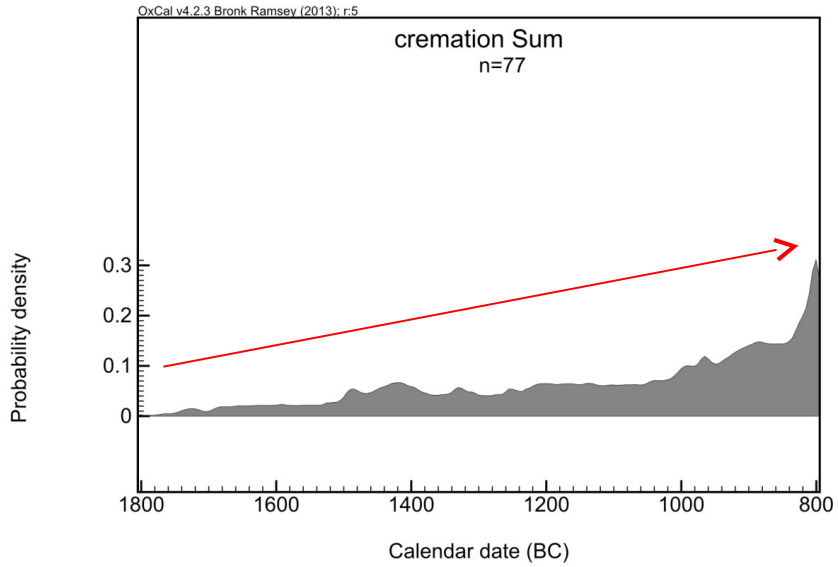
(we did not take into account dates with a standard error greater that 100 years)

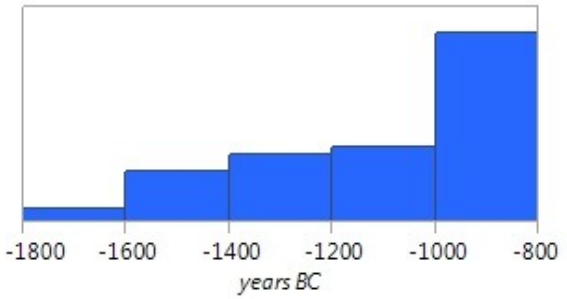
Inhumation burials



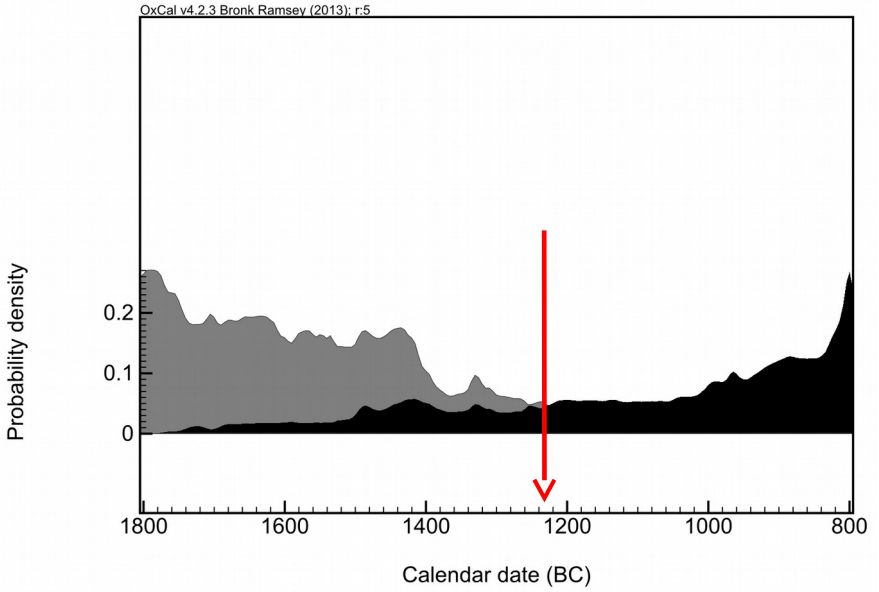


Cremation burials



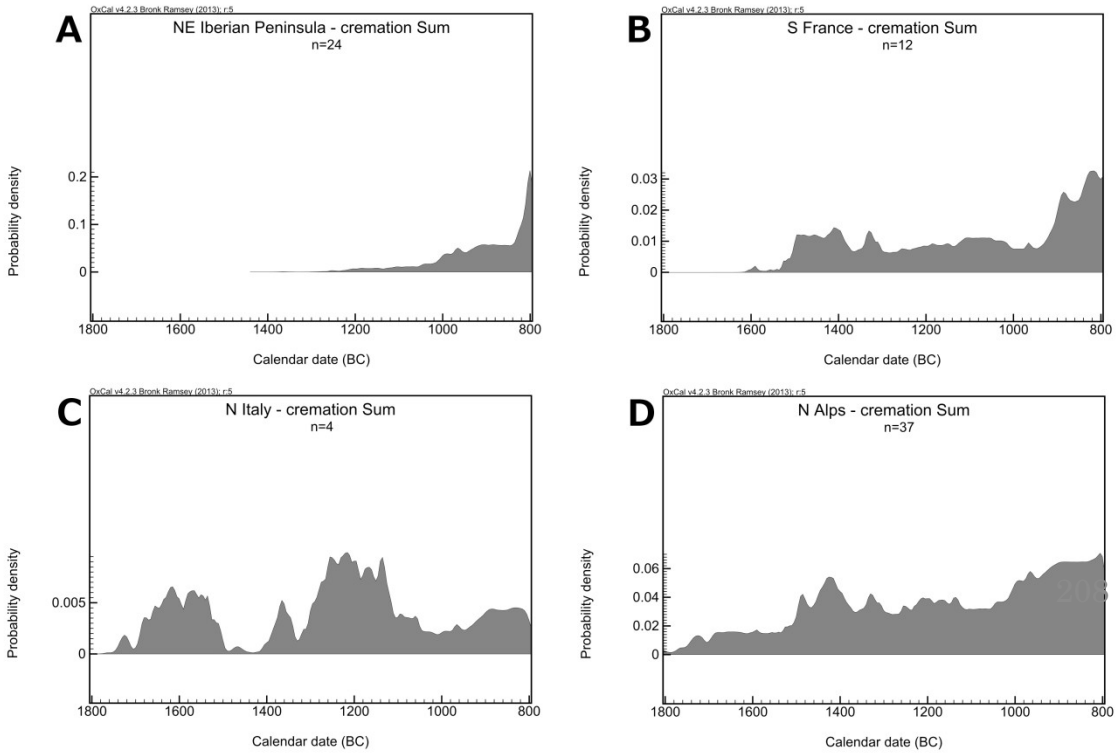


ON A MACRO-SCALE FROM THE EBRO TO THE DANUBE RIVERS



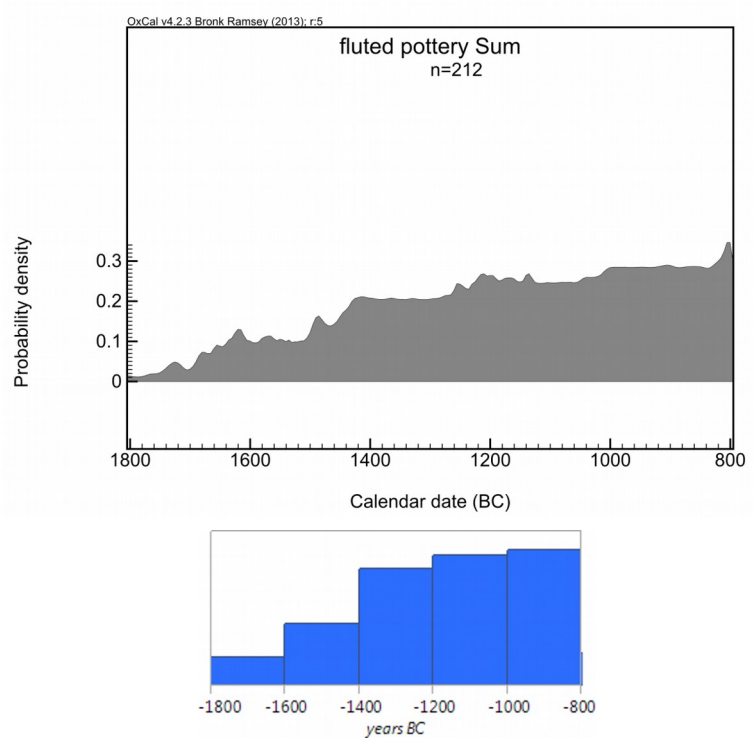
ON A REGIONAL SCALE

SCPDs of ^{14}C-dated cremation burials from: the North-East of Iberian Peninsula (A), Southern France (B), Northern Italy (C) and the north of the Alps region (D).



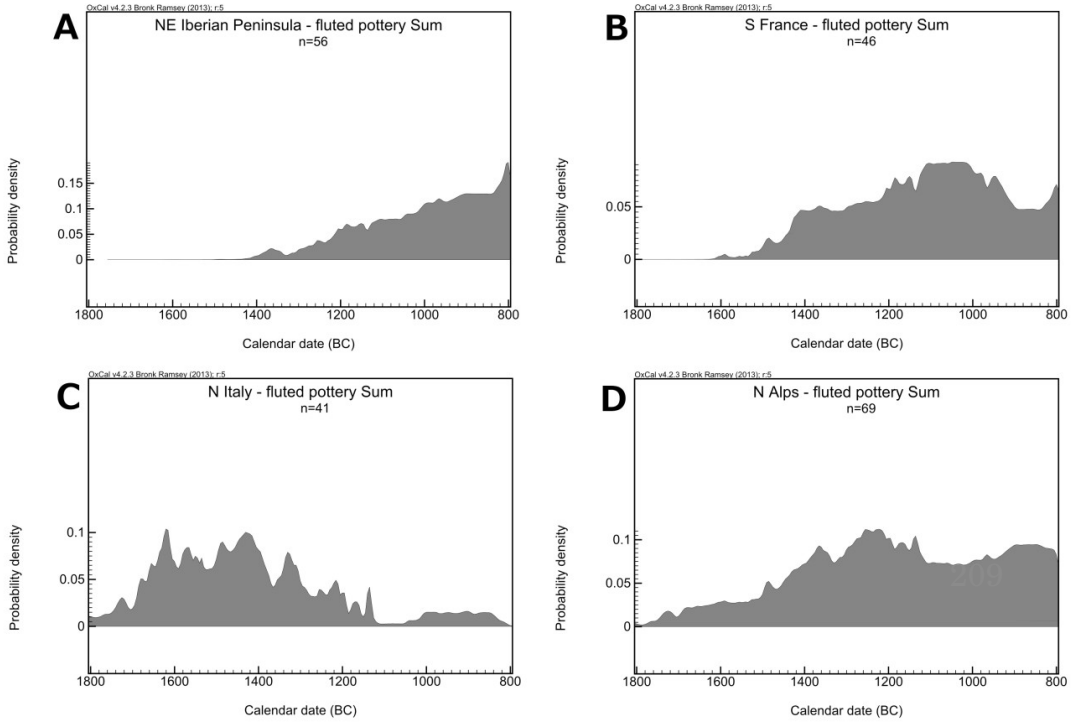
SCPDs AND HISTOGRAMS OF MEDIANS OF ^{14}C-DATED CONTEXTS WITH FLUTED POTTERY INCLUDED IN THE EUBAR DATABASE

(we did not take into account dates with a standard error greater that 100 years)



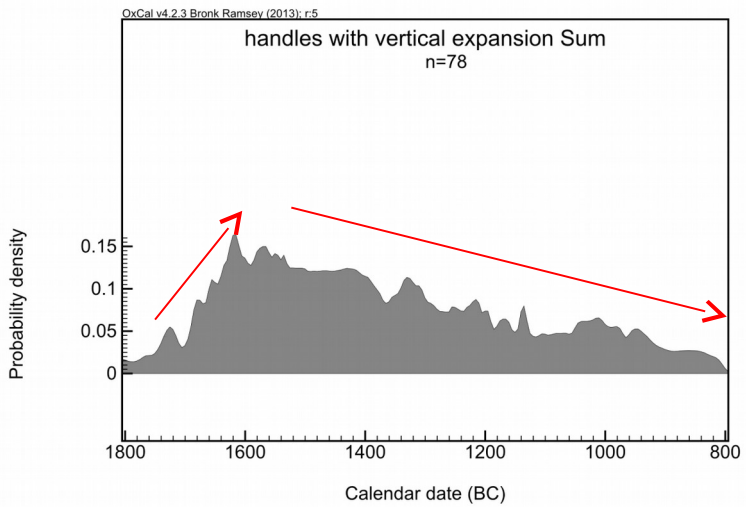
ON A REGIONAL SCALE

ON A MACRO-SCALE FROM THE EBRO TO THE DANUBE RIVERS



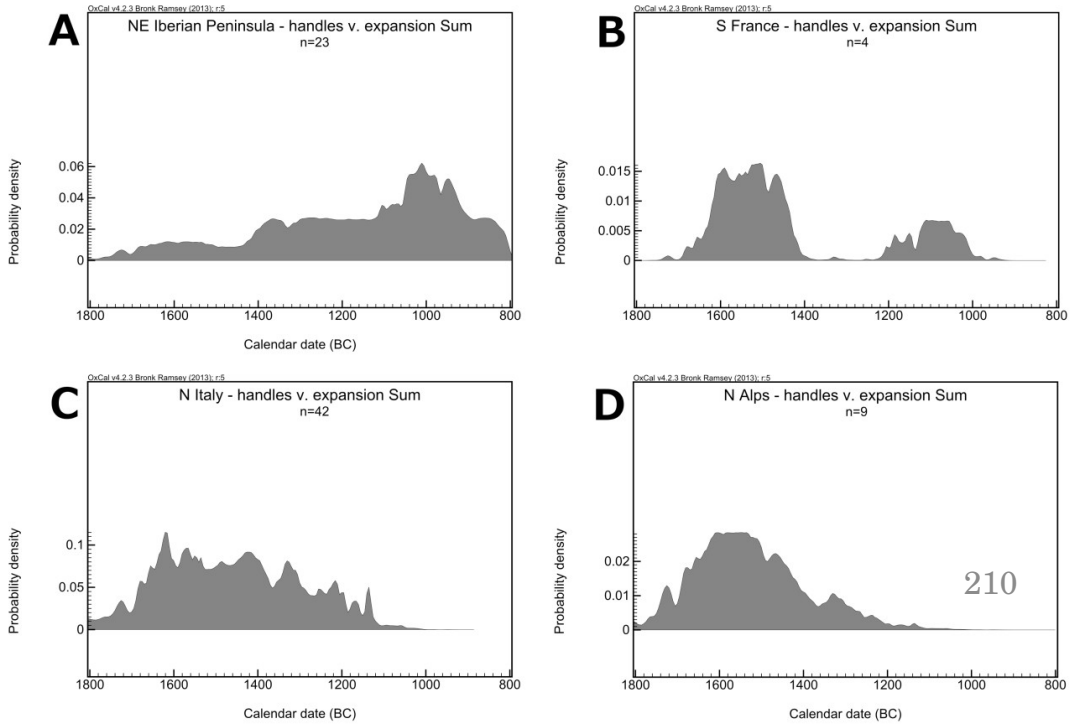
SCPDs AND HISTOGRAMS OF MEDIANS OF CONTEXTS WITH FINDS OF HANDLE WITH VERTICAL EXPANSION INCLUDED IN THE EUBAR DATABASE

(we did not take into account dates with a standard error greater that 100 years)



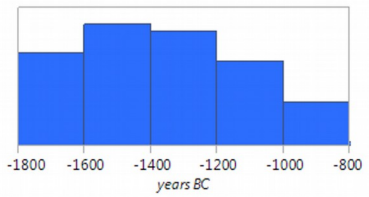
ON A MACRO-SCALE FROM THE EBRO TO THE DANUBE RIVERS

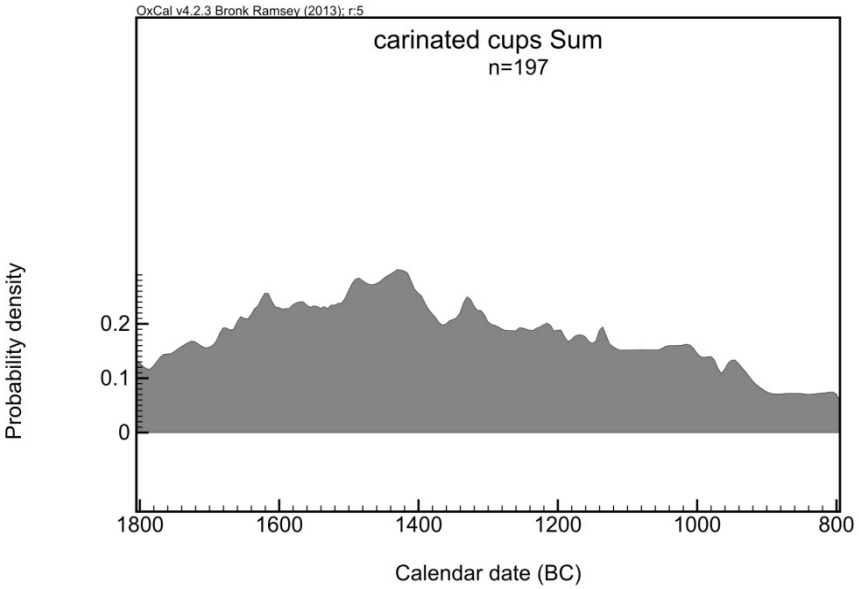
ON A REGIONAL SCALE



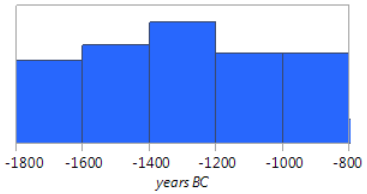
NOT ALL THE VARIABLES CHARACTERIZE THE NEW PERIOD…

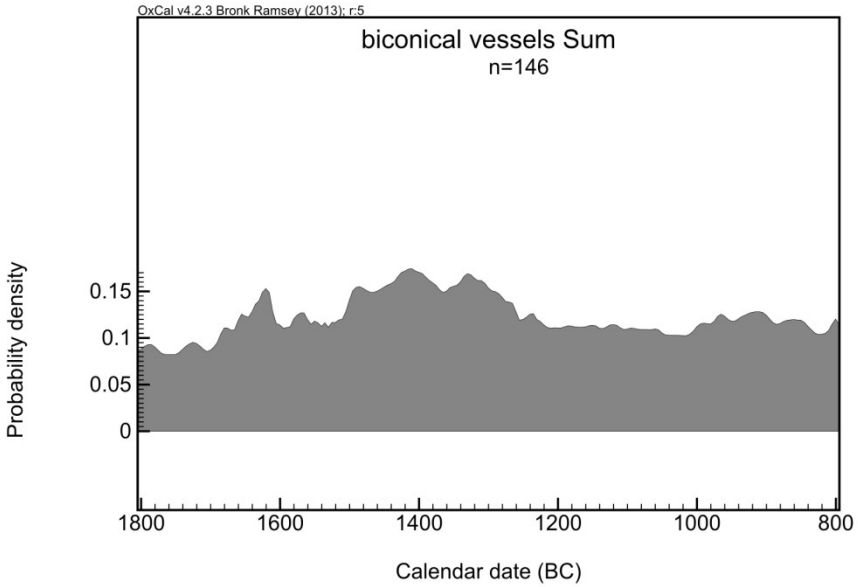
CARINATED CUPS



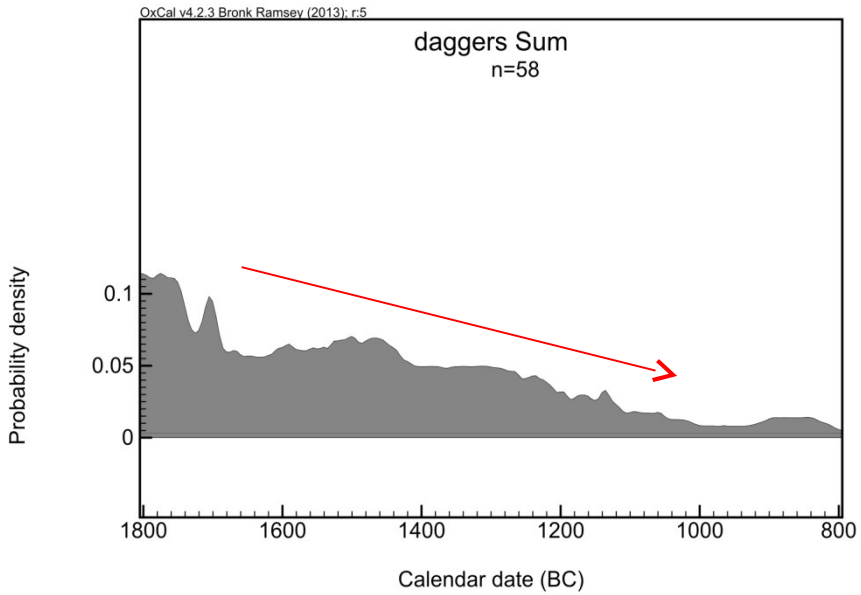


BICONICAL VESSELS

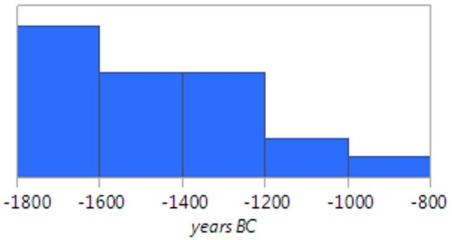


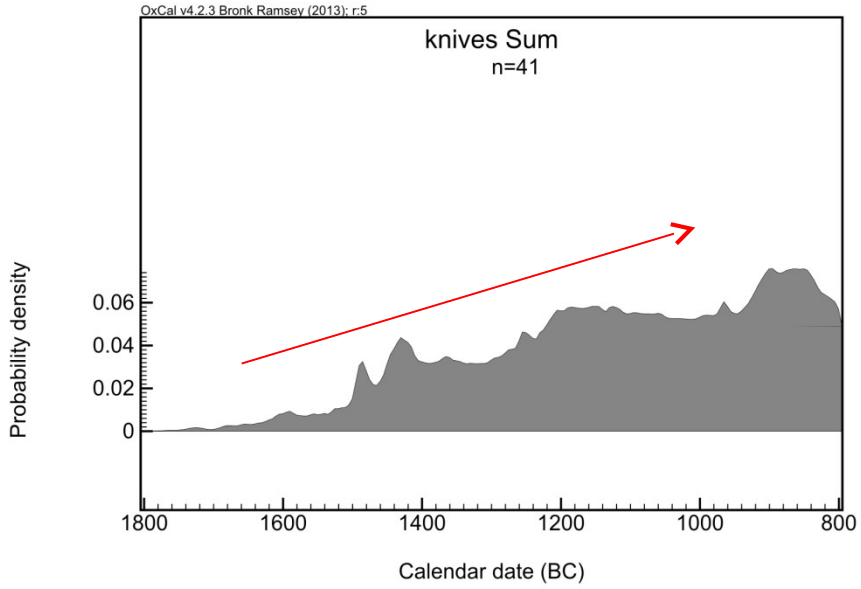


SCPDs AND HISTOGRAMS OF MEDIANS OF RELIABLE CONTEXTS WITH DAGGERS AND METAL KNIVES

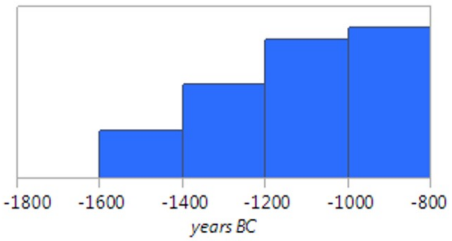


DAGGERS

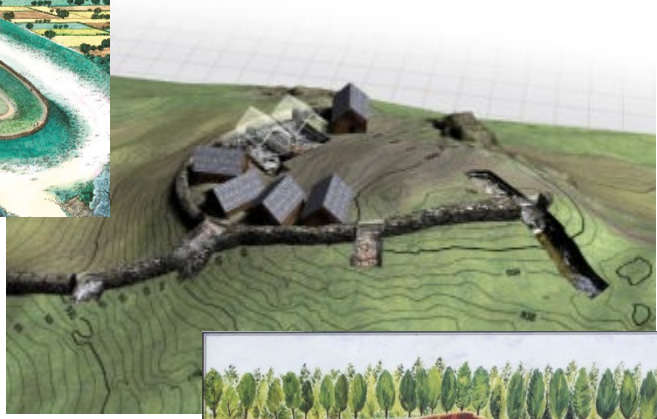


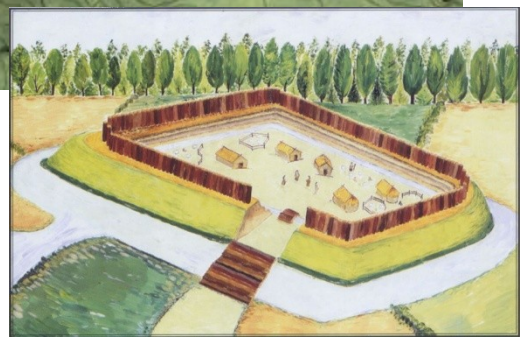


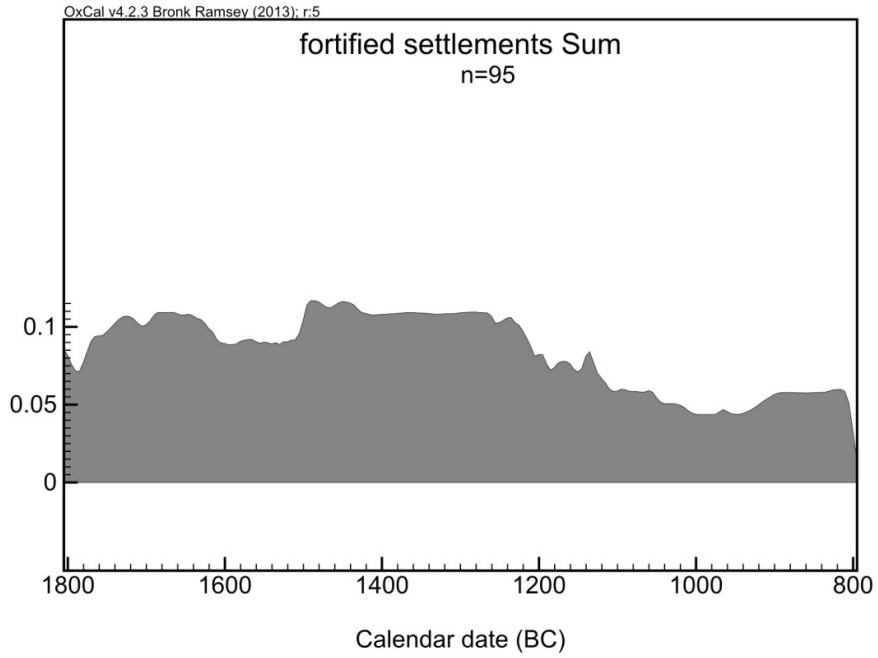
METAL KNIVES

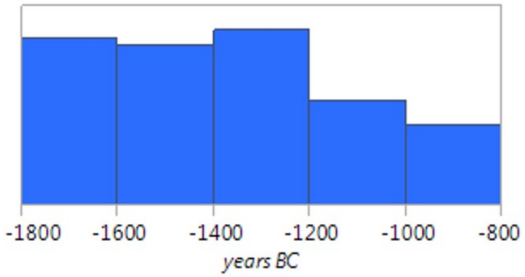


SCPDs AND HISTOGRAMS OF MEDIANS OF FORTIFIED SETTLEMENTS









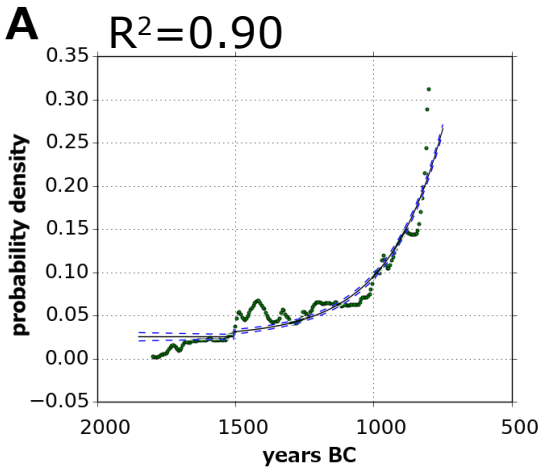
FITTING THE EXPLANATORY MODEL TO ARCHAEOLOGICAL DATA

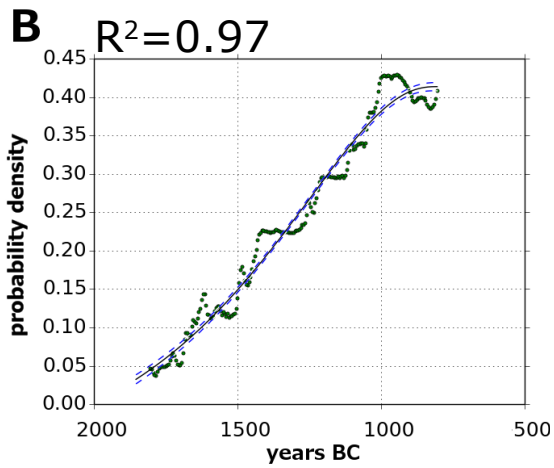
Generalized logistic distribution fitted to SCPDs data

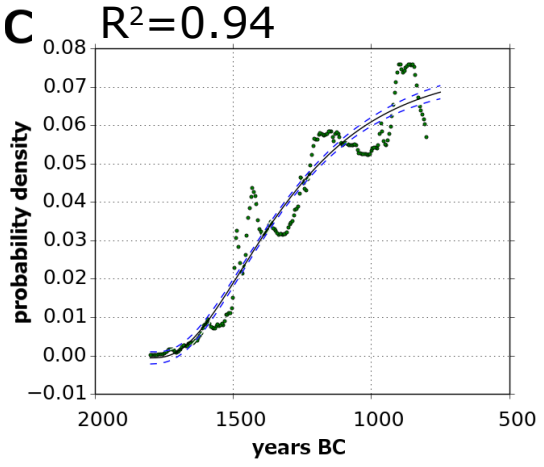
$$Y(t) = A + \frac{K - A}{\left(1 + Qe^{-B(t-M)}\right)^{1/T}}$$

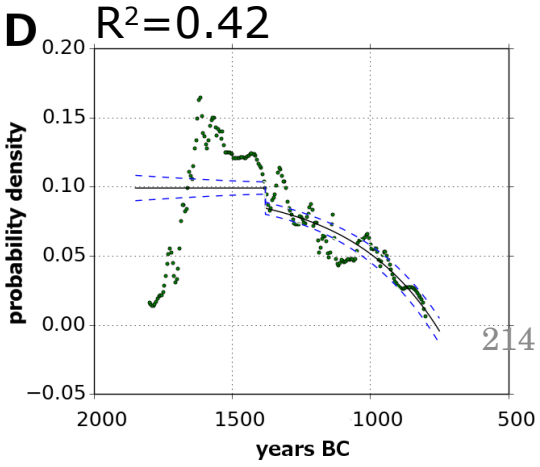
- cremation burials (A)
- fluted pottery (B)
- metal knives (C)
- vases with handles with vertical expansion (D).

The green dots represent the SCPDs, the black line the fitted curve and the dashed blue lines the 95% confidence interval. R^2 is the coefficient of detemination.



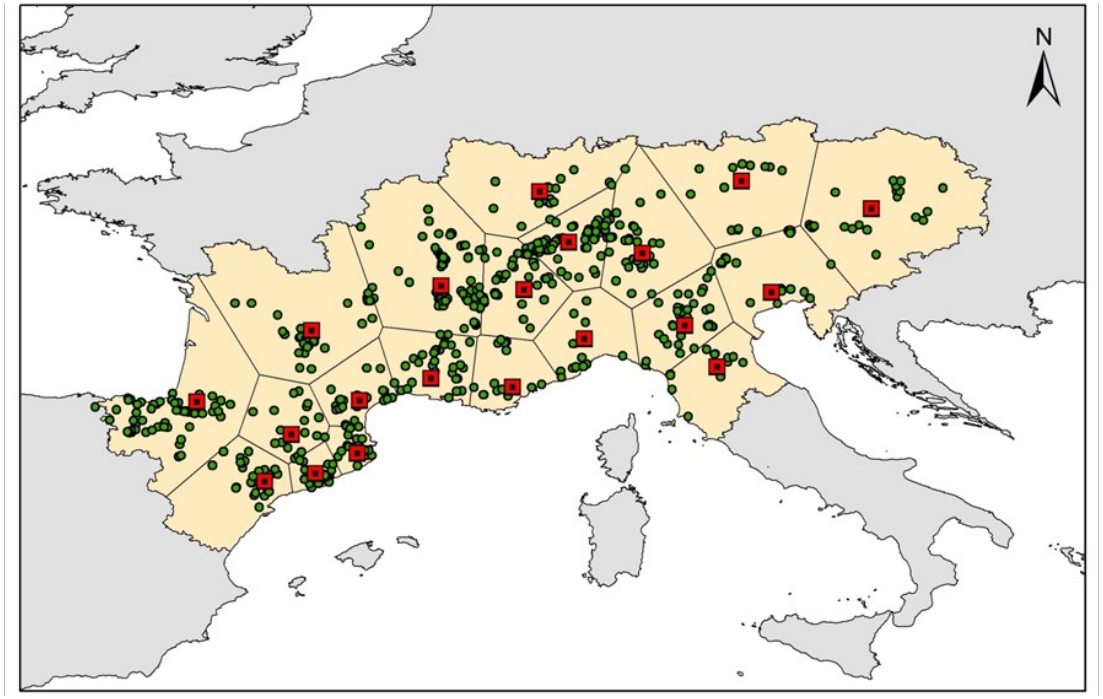


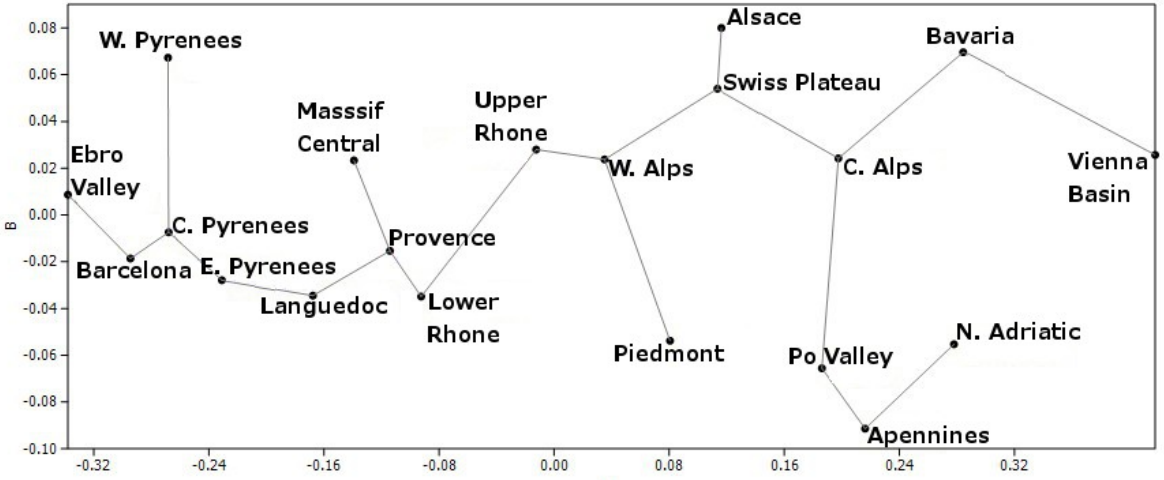




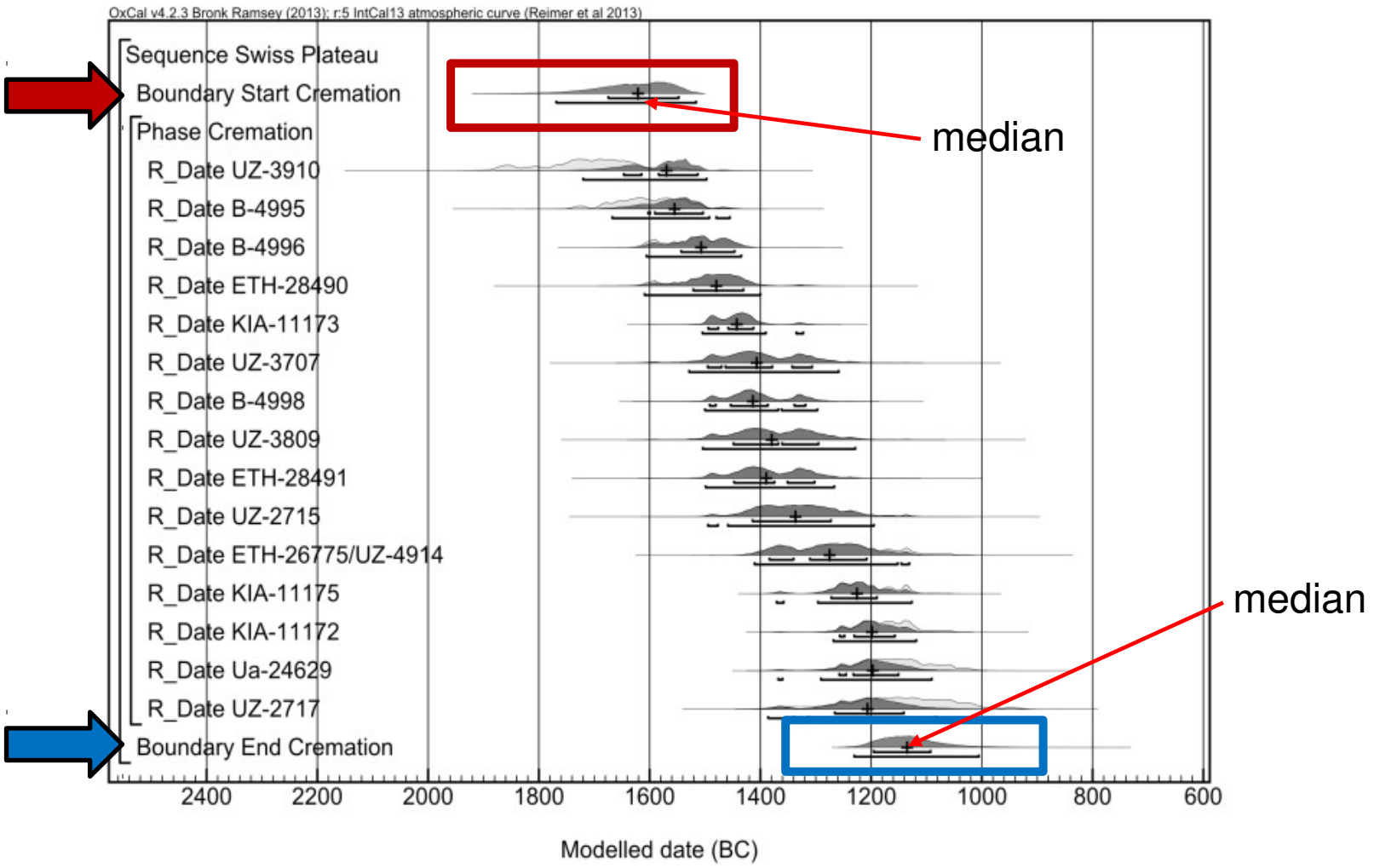
DATA FROM 20 MACRO REGIONS

We took into account 20 regions calculated using Thiessen polygons.
Each region constitutes a buffer zone around one central point.





DATA STRUCTURE: Lower and Upper Boundaries



Survival time (or duration) can be described by two independent parameters, a start event t_a and a finish event t_b.

ARCHAEOLOGICAL DATA FROM 20 GEOGRAPHICAL REGIONS

Region	Funerary ritual	Lower Boundary	Upper Boundary
Ebro Valley	Inhumation	1800	1519
Ebro Valley	Cremation	821	800
Barcelona	Inhumation	1800	1334
Barcelona	Cremation	997	800
W. Pyrenees	Inhumation	1800	1517
W. Pyrenees	Cremation	896	800
C. Pyrenees	Inhumation	1800	744
C. Pyrenees	Cremation	1358	800
E. Pyrenees	Inhumation	1800	890
E. Pyrenees	Cremation	960	800
Languedoc	Inhumation	1800	1435
Piedmont	Cremation	1375	800
Po Valley	Inhumation	1800	1765
Po Valley	Cremation	1600	800
Apennines	Inhumation	-	-
Apennines	Cremation	-	-
N. Adriatic	Inhumation	1800	1496
N. Adriatic	Cremation	1380	800
Vienna Basin	Inhumation	1800	782
Vienna Basin	Cremation	1255	800

Region	Funerary ritual	Lower Boundary	Upper Boundary
Ebro Valley	Inhumation	1800	1519
Ebro Valley	Cremation	821	800
Barcelona	Inhumation	1800	1334
Barcelona	Cremation	997	800
W. Pyrenees	Inhumation	1800	1517
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C. Pyrenees	Inhumation	1800	744
C. Pyrenees	Cremation	1358	800
E. Pyrenees	Inhumation	1800	890
E. Pyrenees	Cremation	960	800

CREATION OF TWO SURVIVAL TIME TABLES:

a) for measuring the survival of traditional cultural feature (INHUMATION)
b) to estimate the temporal delay in adopting the cultural change (CREMATION)

T_i : positive number indicating the number of calendar years

- **SURVIVAL TIME TABLE A:** **survival of BA traditions has been calculated as the difference between time 0 (1800 BC) and the median of Bayesian interval for the last occurrences of inhumantions in a region within the studied period**

REGION	INHUMATION SURVIVAL TIME (number of calendar years since 1800 BC until the last occurrence)
Ebro Valley	281
Barcelona	466
W. Pyrenees	283
C. Pyrenees	1056
E. Pyrenees	910
Languedoc	365
Massif Central	651

- **SURVIVAL TIME TABLE B:**

the delay in adopting the funerary ritual has been calculated as the difference between time o (1800 BC) and the median of the Bayesian interval for the first occurrence of cremations in a region within the studied period

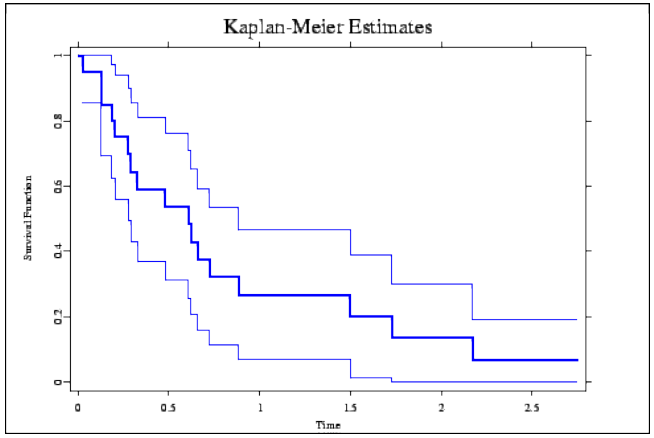
REGION	CREMATION ADOPTION (number of calendar years since 1800 BC until the first occurrence)
Ebro Valley	979
Barcelona	803
W. Pyrenees	904
C. Pyrenees	442
E. Pyrenees	840
Languedoc	815
Massif Central	760

THE SURVIVAL OF INHUMATION IN BRONZE AGE EUROPE

SURVIVAL OF INHUMATION BURIAL AS A TRADITIONAL BURIAL PRACTICE

ANALYSIS CONCERS THE DURATION OF THE LAST ARCHAEOLOGICAL EVIDENCES OF INHUMATION

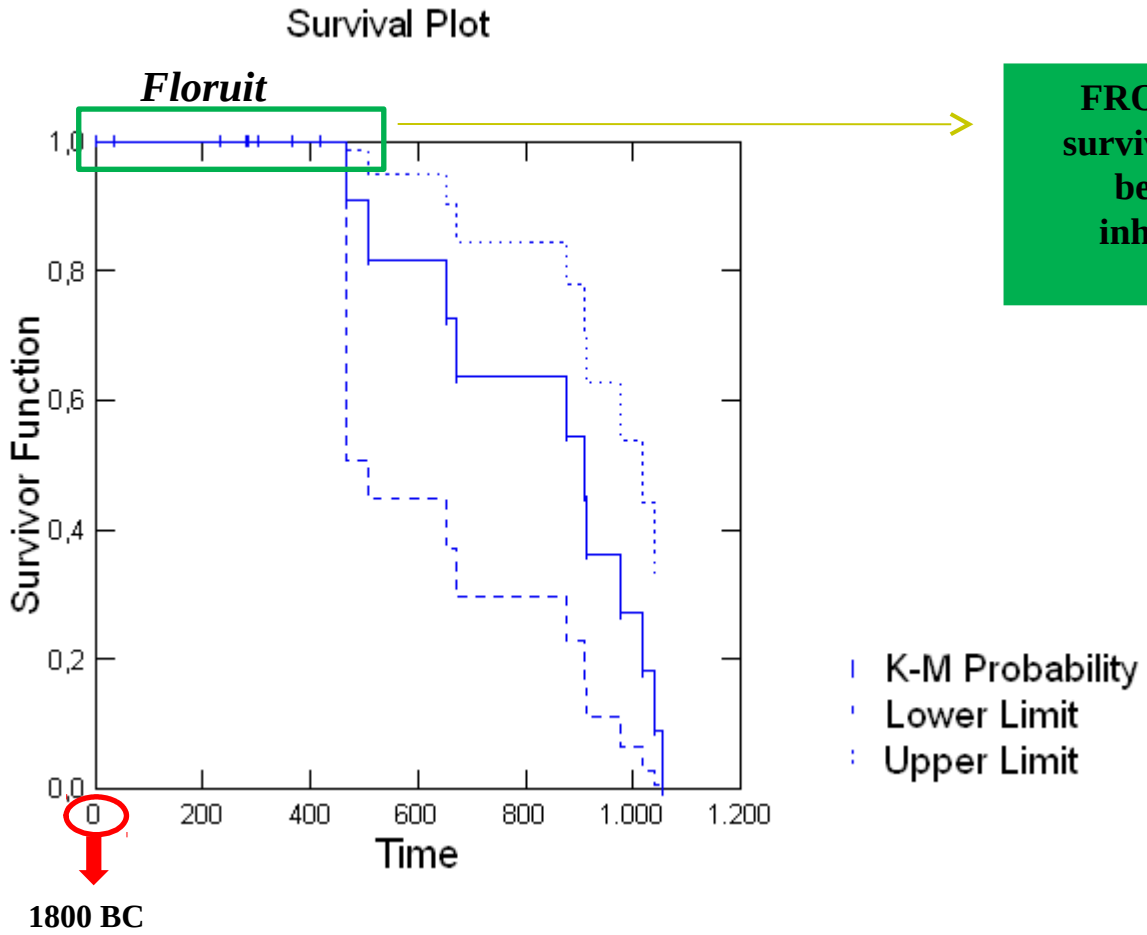
KAPLAN-MEIER ESTIMATOR OF THE SURVIVAL FUNCTION



$$S_{KM}(t_l) = \prod_{k=1}^{l} \left(1 - \frac{d_k}{n_k}\right).$$

Let $0 < t_1 < t_2 < t_l < \ldots < t_L$ be the ordered (continuous) time points at which events occur, n_l is the number of cases at the risk right after t_{l-1} and d_l the number of events at time point t_l. Note that nl equals n_{l-1} minus the number of events and the number of censored cases in time interval l. Values are plotted using a 95% confidence interval

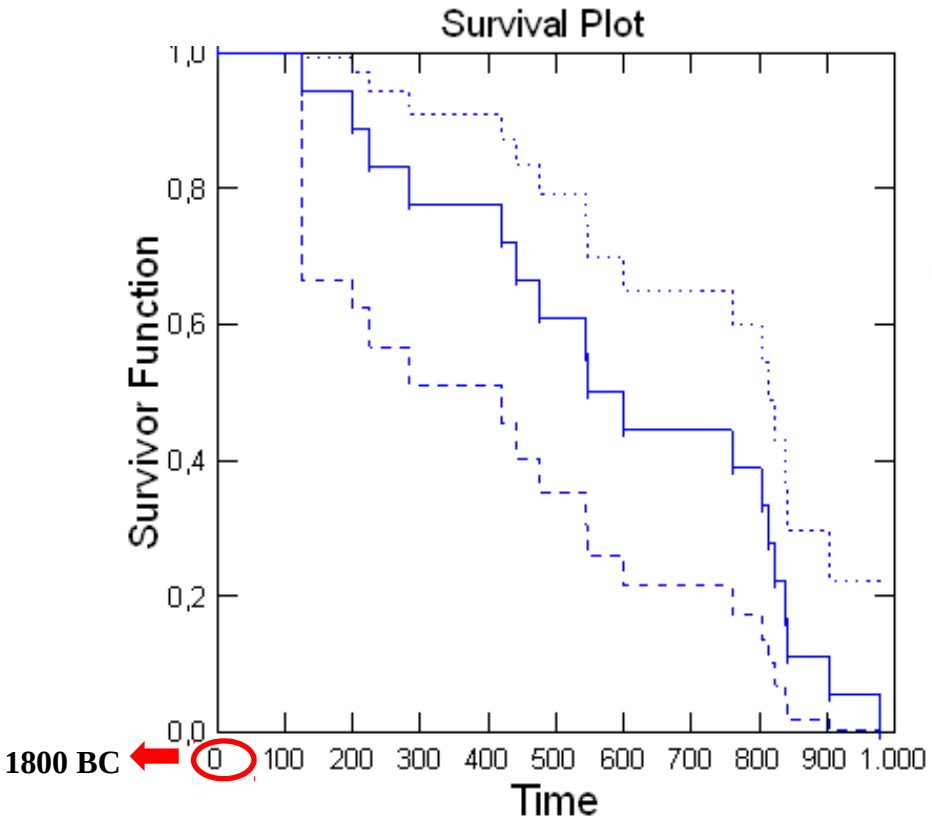
THE SURVIVAL OF INHUMATION IN BRONZE AGE EUROPE



FROM 1800 TO 1450 survival probability is 1 because there are inhumation burials everywhere

From 1450 onwards, the probability of this particular tradition surveying begins to decrease. In 150 years, probability decrease 20%. After a relatively short period without further changes (from 1230 to 1120 BC), the curve record a sudden decrease of additional 20%. Around 1120 BC inhumation survived in 60% of regions from the Alps to the Mediterranean. From 950 BC on, in 100 years the probability of inhumation survival decreases more than a 50%.

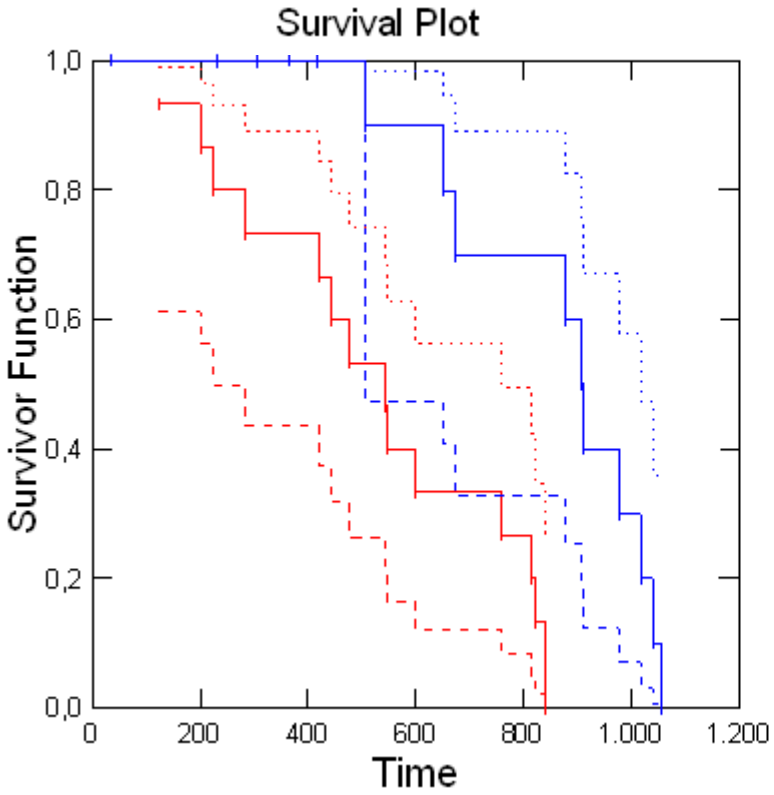
THE DELAY OF CREMATION BURIALS IN BRONZE AGE EUROPE



The resulting cumulative survival curve represents the proportion of regions that will resist to cultural change at least a given period of time (delay).

Until 1700 BC resistance to cultural change is maximum because inhumation is at its "floruit". The first occurrence of cremation can be understood as a sequence of fast but relatively unimportant occurrences of the new ritual. At 1500 BC, cultural delay was high enough (80%). The probability of cultural change resistance maintains for another 100 years, after which decreases quickly, 40% in 200 years. At 1200 BC a majority of regions have adopted the new cultural practice. From 1000 BC onwards, the dynamics of cultural change increase, so that at 750 BC all regions from the Alps to the Mediterranean have adopted cremation rite.

THE RELATIONSHIP BETWEEN THE SURVIVAL OF TRADITIONS AND THE ADOPTION OF NEW CULTURAL FEATURES



Log-Rank test using Mantel and Haenszel statistic produced a *p-value* of 0.000, which suggests that there are relevant differences between both curves, indicating that survival of old traditions and resistance to adopt innovations were not temporally correlated in a linear way.

K-M Probability Lower Limit Upper Limit

Cremation Cremation Cremation

Inhumation Inhumation Inhumation

The probability of survival of the tradition was always higher that the probability of resistance to change. Cremation in no case substituted entirely the previous ritual. The moment at which 50% of studied regions maintained the old tradition (1000 BC) is more recent than the moment at which 50% of regions adopted the new funerary ritual (1200 BC). Part of the explanation lies in the quality of data used, and the relevance of right-censoring in the case of inhumation burials. When a majority of regions (50%) adopted the new ritual (1200 BC), 90% of regions still used the traditional practice.

THE PROBABILITIES OF CULTURAL CHANGE AT THE END OF BRONZE AGE

Hazard function of adopting a new ritual at the end of Bronze Age

Use of a different data set

time 0 as the median of the Bayesian interval for the region where cremation first occurred

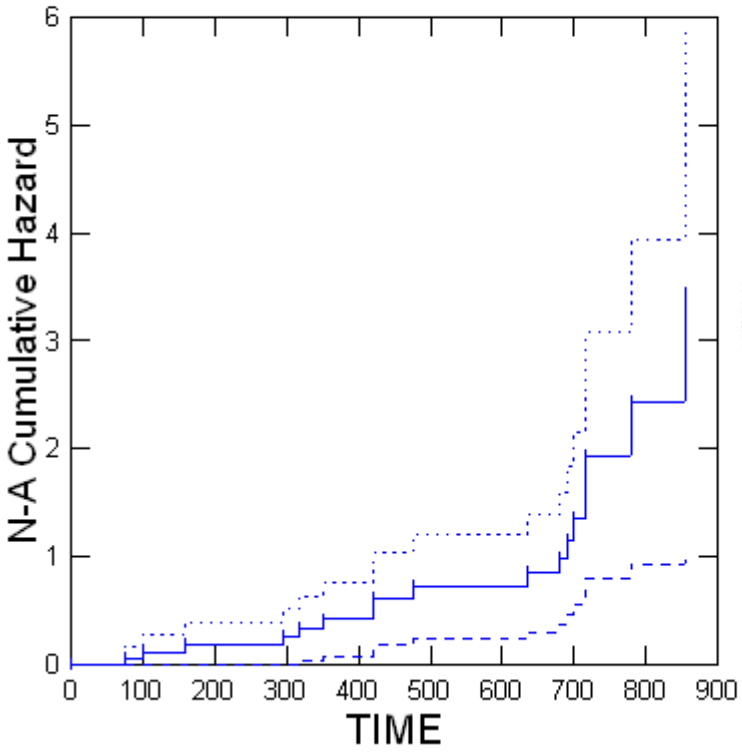
Region	N. Region	Time from 0 (Swiss Plateau)
Ebro Valley	1	854
Barcelona	2	678
W. Pyrenees	3	779
C. Pyrenees	4	317
E. Pyrenees	5	715
Languedoc	6	690
Massif Central	7	635
Provence	8	159
Lower Rhone	9	475
Upper Rhone	10	352
Alsace	11	422
W. Alps	12	717
Swiss Plateau	13	0

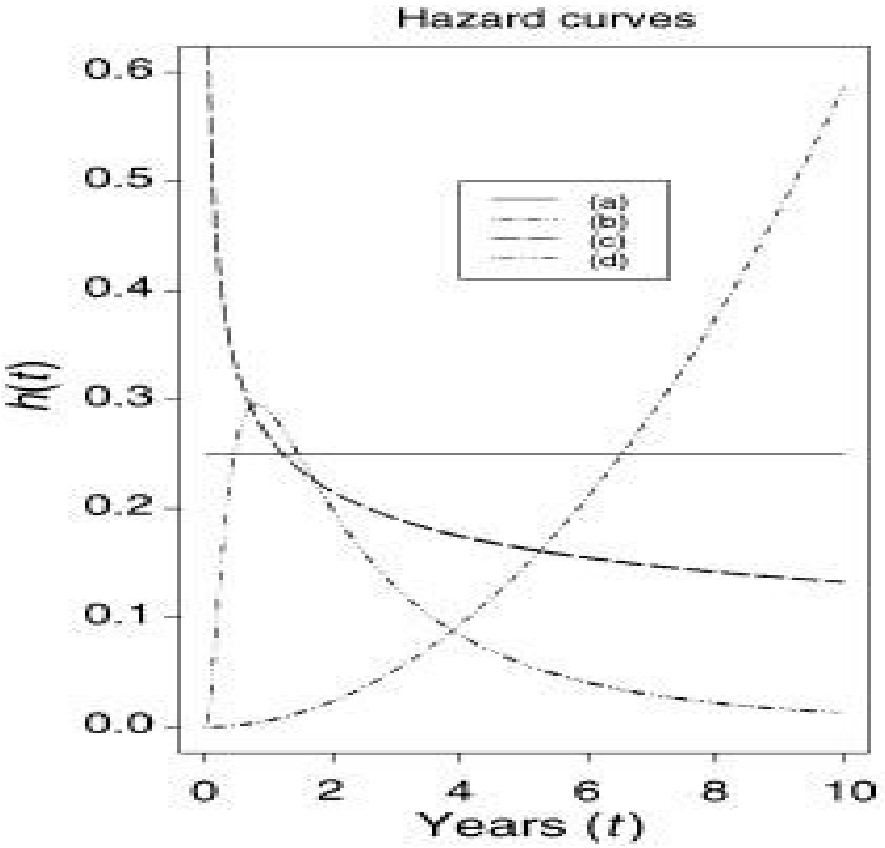
1675 BC= 0

We can plot the cumulative hazard function $H(t)$, or rather an estimate of it. We have used the Nelson-Aalen estimator:

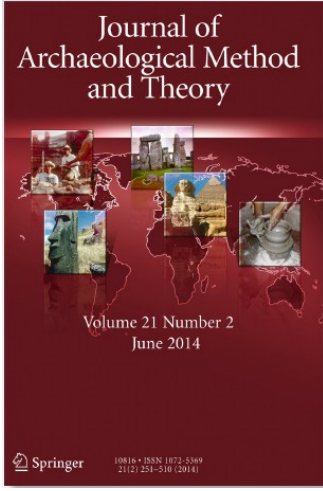
$$H_{NA}(t_l) = \sum_{k=1}^{l} \frac{d_k}{n_k}.$$

N-A Cumulative Hazard Plot





BARCELÓ JA, CAPUZZO G, BOGDANOVIĆ I. 2014. Modeling expansive phenomena in early complex societies: the Transition from Bronze to Iron Age in Prehistoric Europe. *Journal of Archaeological Method and Theory* 21(2):486-510.



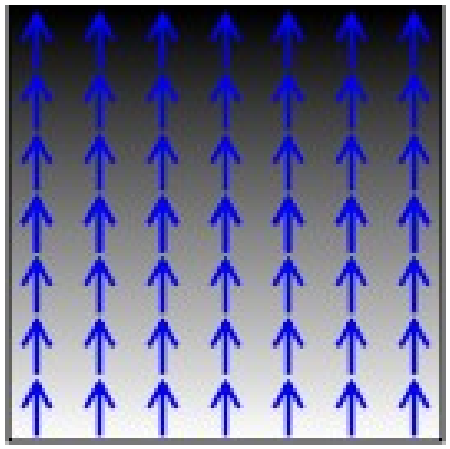
SPACE-TIME DIFFUSION OF THE ADOPTED INNOVATIONS

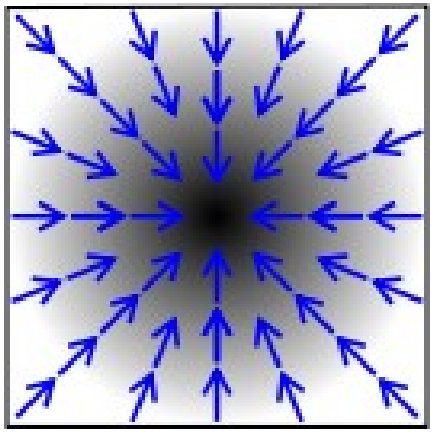
DETECTING A SPACE-TIME GRADIENT

Expansive phenomena in archaeology

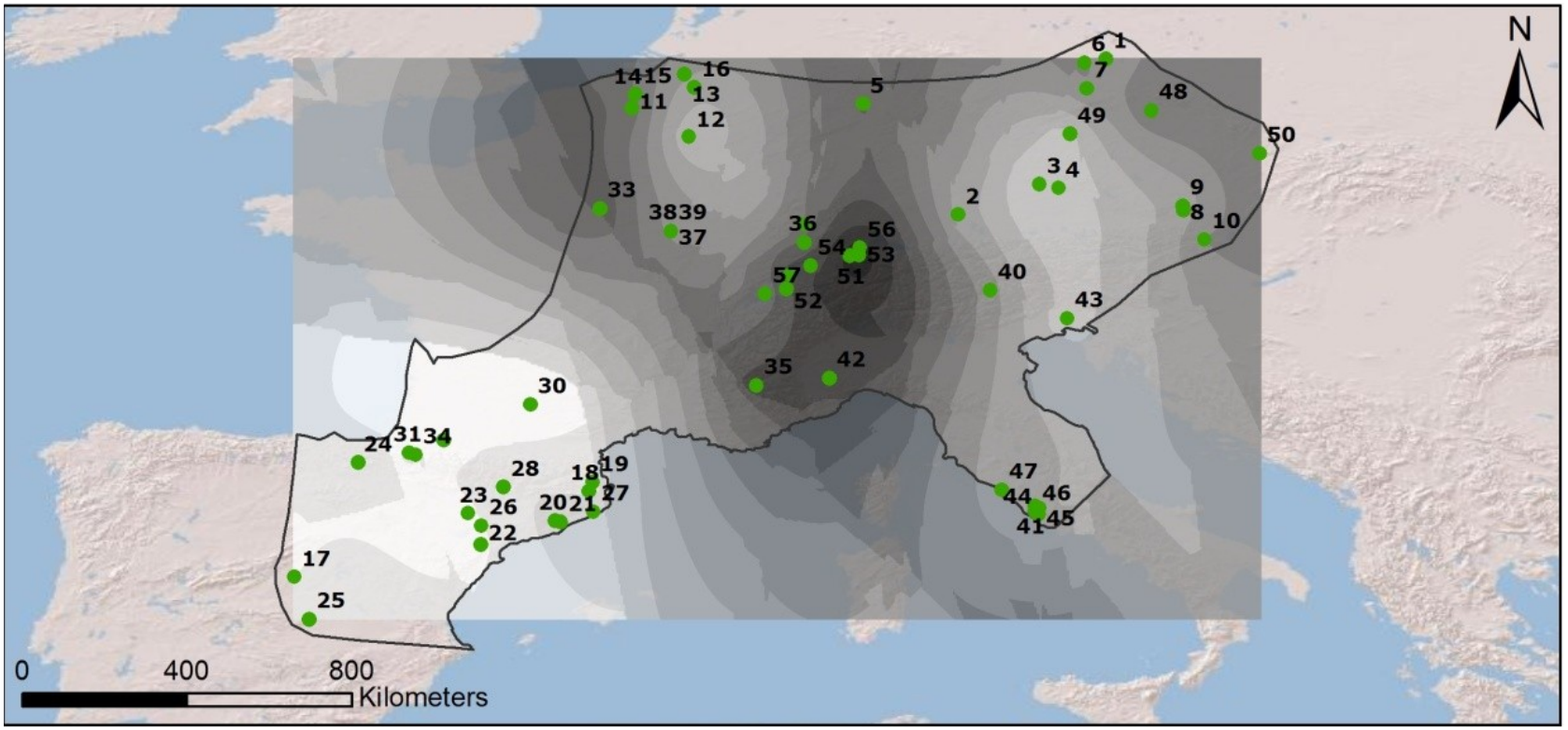
When a system expands through time, we can foresee a certain degree of dependence between locations, and this dependence is exactly what gives an appearance of unity to the process.

The formal conditions for an expansive phenomenon are the existence of a spatial gradient and directivity, which implies a similarity in neighboring regions (Tobler's Law).



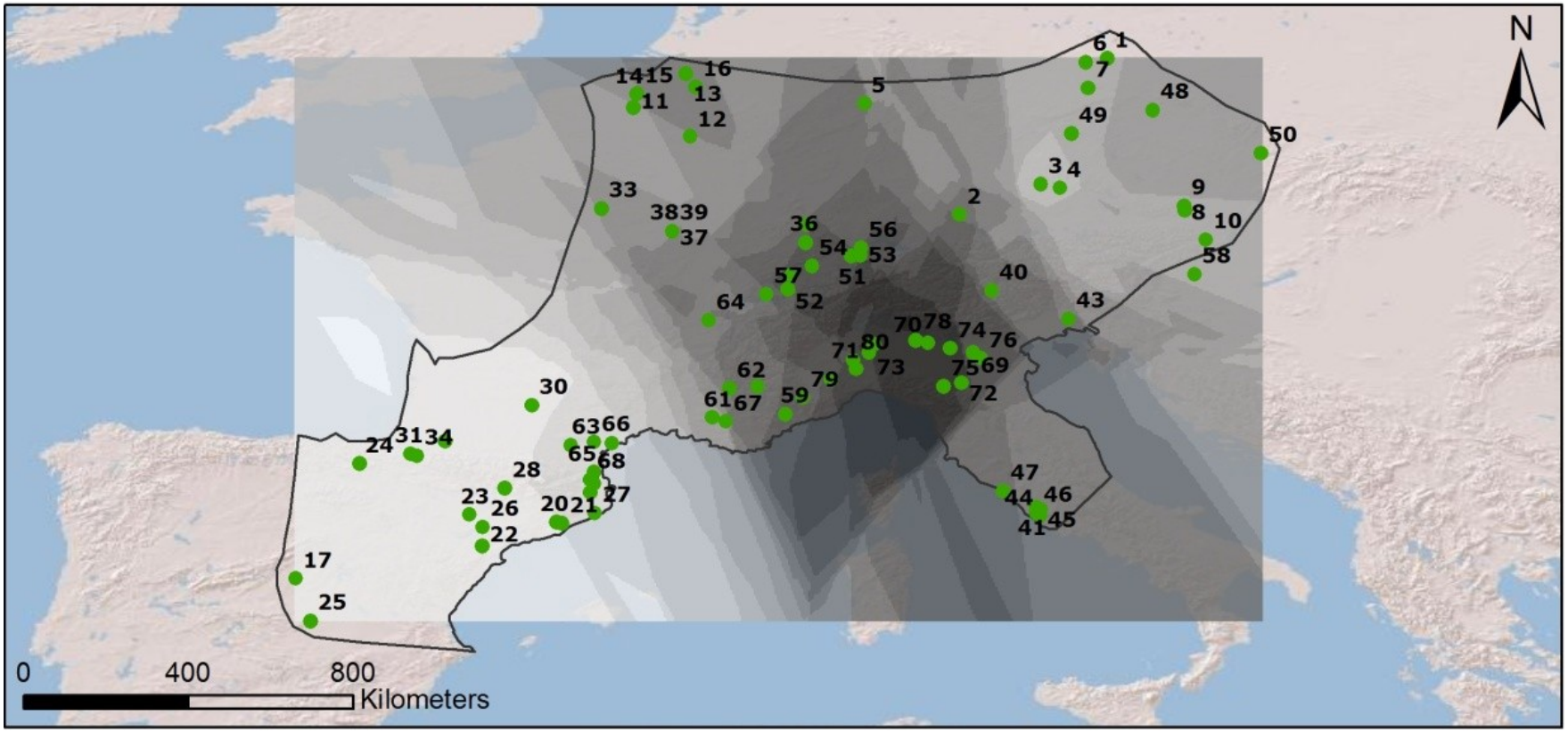


MODELING THE FIRST OCCURRENCE OF CREMATION BURIALS BETWEEN 1800 AND 800 BC IN PROTOHISTORIC EUROPE



Space-time variations in the first occurence of cremation burials (medians of the calibrated ^{14}C dates). Interpolation has been calculated using a kriging algoritm. Countours represent differences of 50 years. Direccionality of the adoption of cremation phenomenon.
We have detected an average rate of expansion of 0.6-1km/year.

SPATIAL AND TEMPORAL VARIATIONS IN THE FIRST OCCURRENCE ^{14}C AND TYPOLOGICALLY DATED CREMATION BURIALS

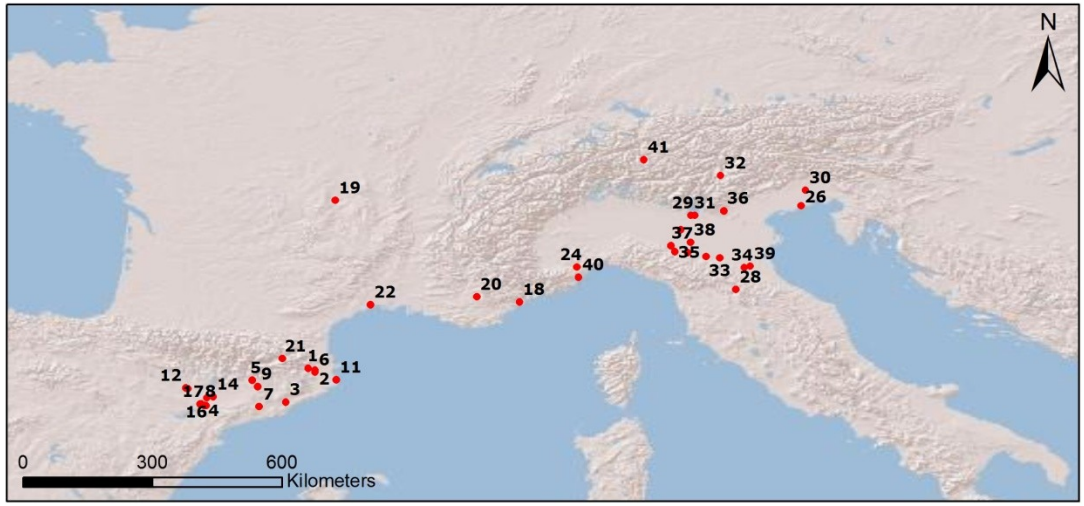


Contours represent differences of 50 years

DIRECTIVITY OF THE 2ND MILLENNIUM CREMATION ADOPTION PHENOMENON

The map contains small arrows at each grid node pointing down the gradient, that is, decrease in chronology: from places where cremations were older to places where such phenomenon appears to be more recent.

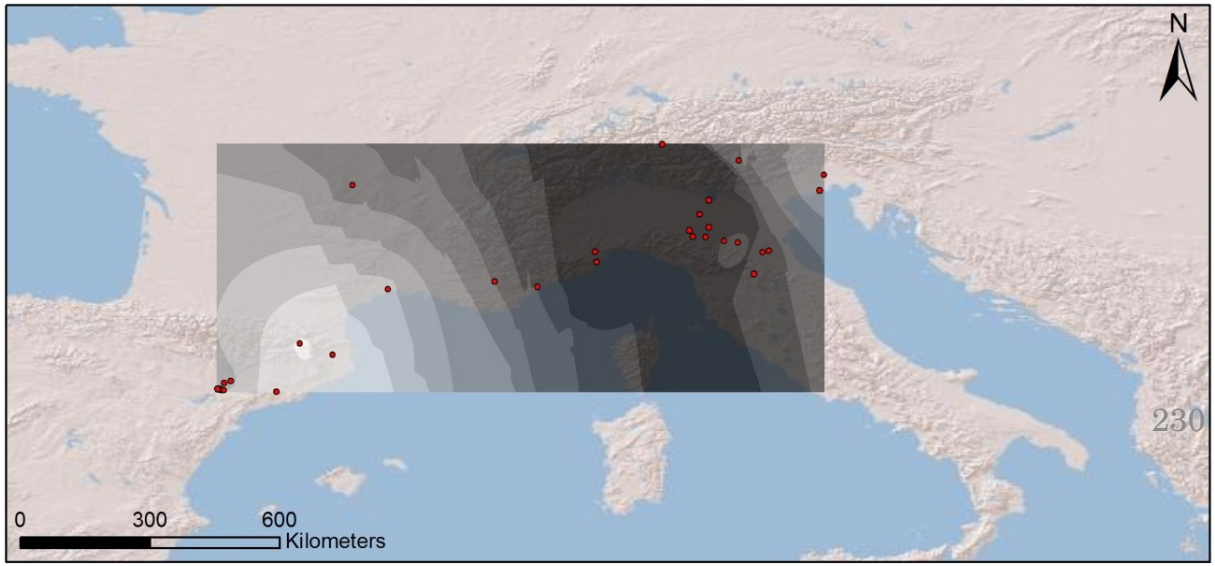
THE DIFFUSION OF VASES WITH HANDES WITH VERTICAL EXPANSION IN THE MIDDLE AND LATE BRONZE AGE



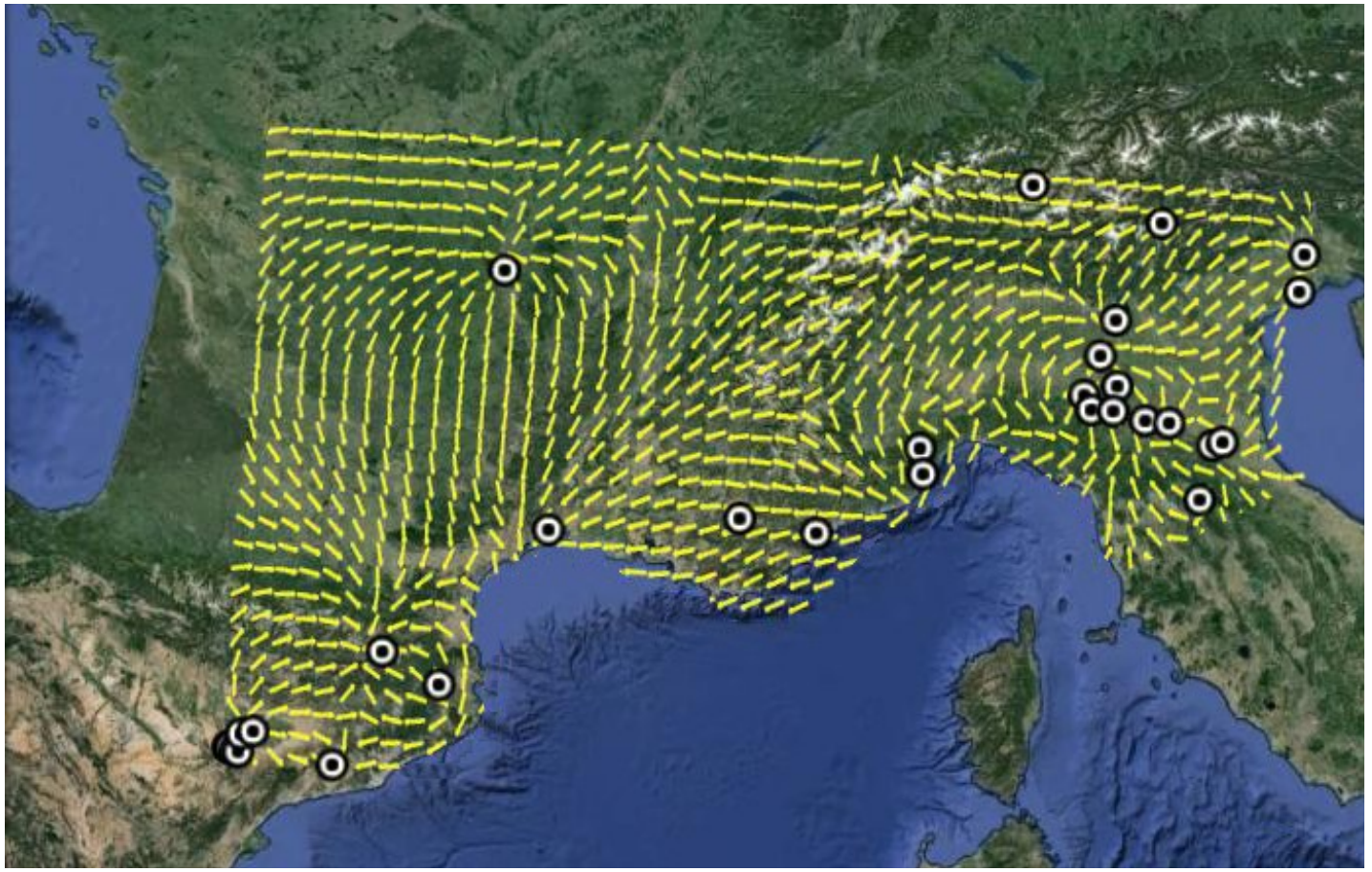
Sample prescreening

From East to West spatio-temporal gradient.

Contours represent differences of 50 years.

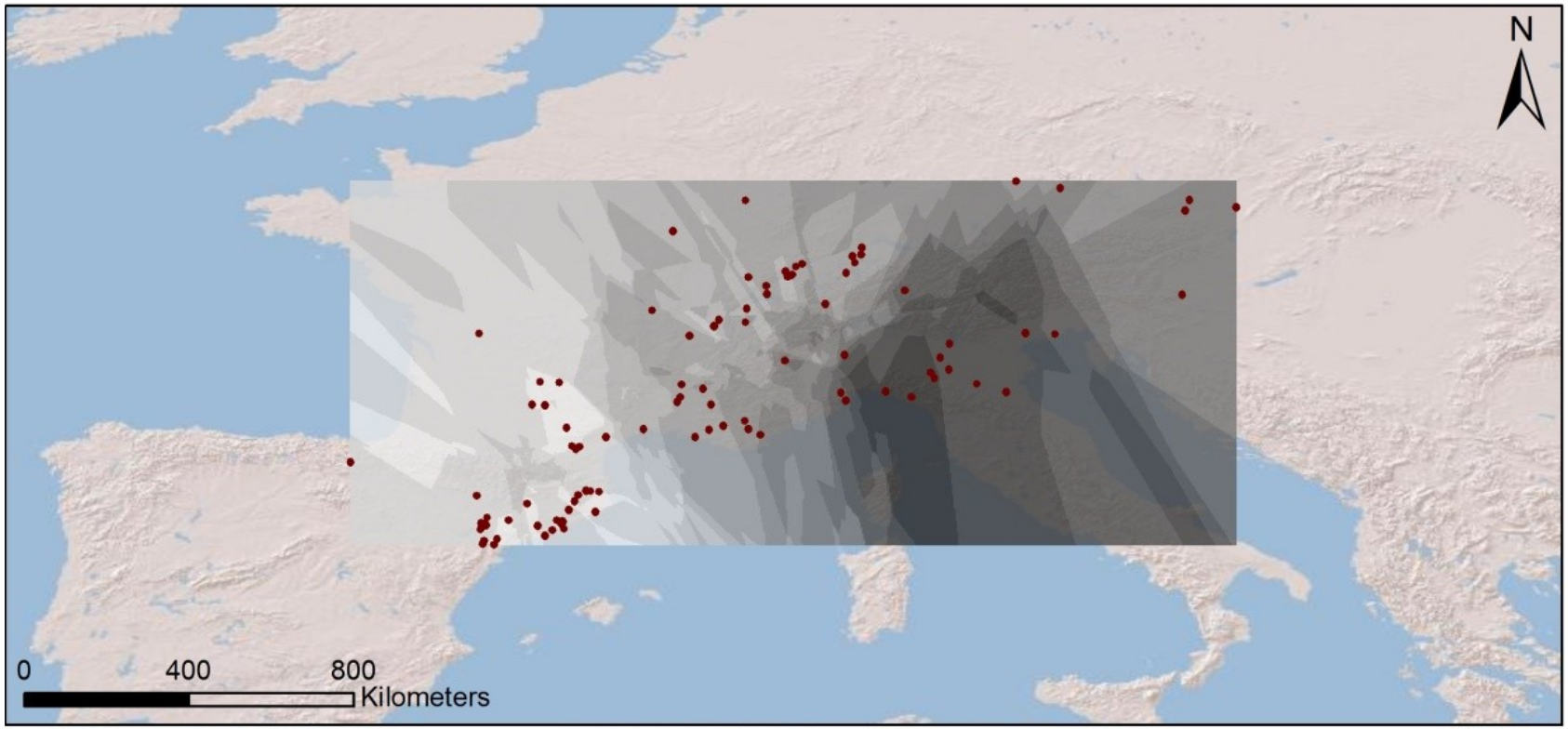


THE DIFFUSION OF VASES WITH HANDES WITH VERTICAL EXPANSION IN THE MIDDLE AND LATE BRONZE AGE: FROM EAST TO WEST



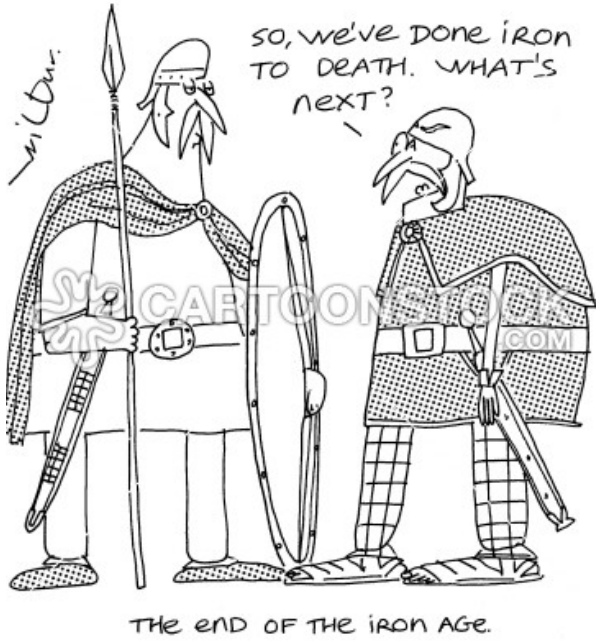
Map showing the directivity of the vases with handles with vertical expansion adoption phenomenon

NOT ALL THE DIFFUSION PROCESSES FOLLOW THE WAVE OF ADVANCE MODEL…



Spatial and temporal variations in the first occurrence of contexts characterized by the presence of fluted pottery included in the EUBAR database (medians of the calibrated radiocarbon dates). Contours represent differences of 50 years.

CONCLUSIONS:
Cultural Change at the End of Bronze Age



Capuzzo, G., Barceló, J.A, 2015, "Cultural Changes in the 2nd Millenium BC: A Bayesian examination of Radiocarbon Evidence from Switzerland and Catalonia. *World Archaeology*, Vol. 47, Issue 4. doi: 10.1080/00438243.2015.1053571.

Capuzzo, G., Boaretto, E., Barceló, J.A. 2014, EUBAR: A Database of 14C Measurements for the European Bronze Age. A Bayesian Analysis of 14C-Dated Archaeological Contexts from Northern Italy and Southern France. *Radiocarbon*, vol. 56, DOI: 10.2458/56.17453.

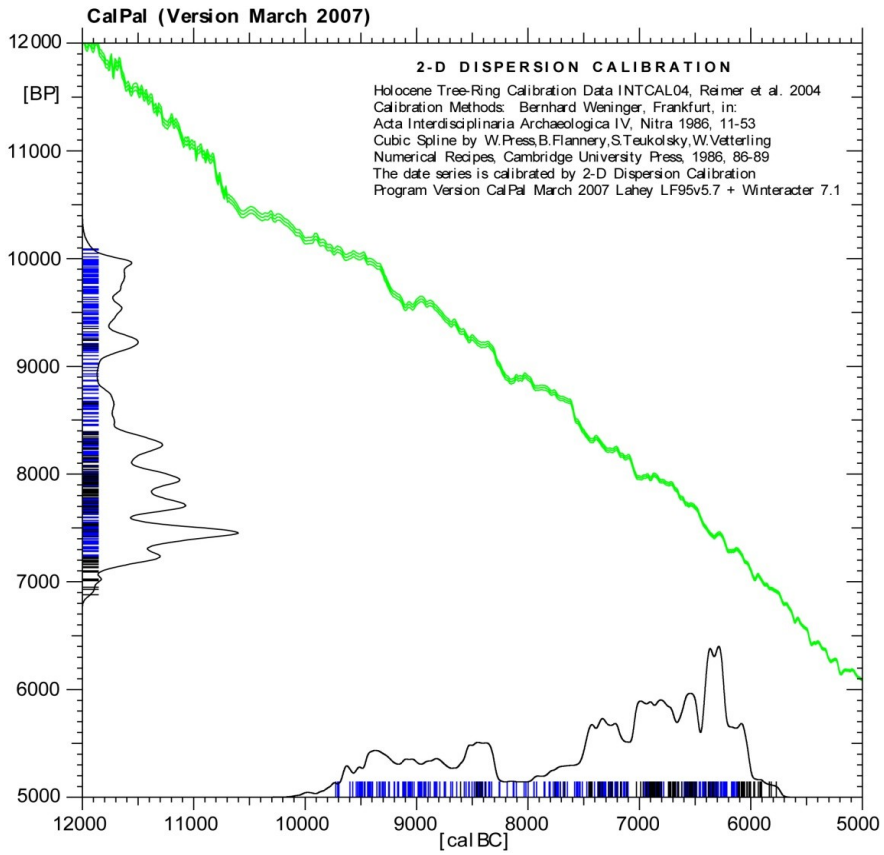
Barceló, J.A., Capuzzo, G., Bogdanovic, I., 2014, "Modeling Expansive Phenomena in early Complex Societies. The Transition from Bronze to Iron Age in Prehistoric Europe". *Journal of Archaeological Method and Theory* (

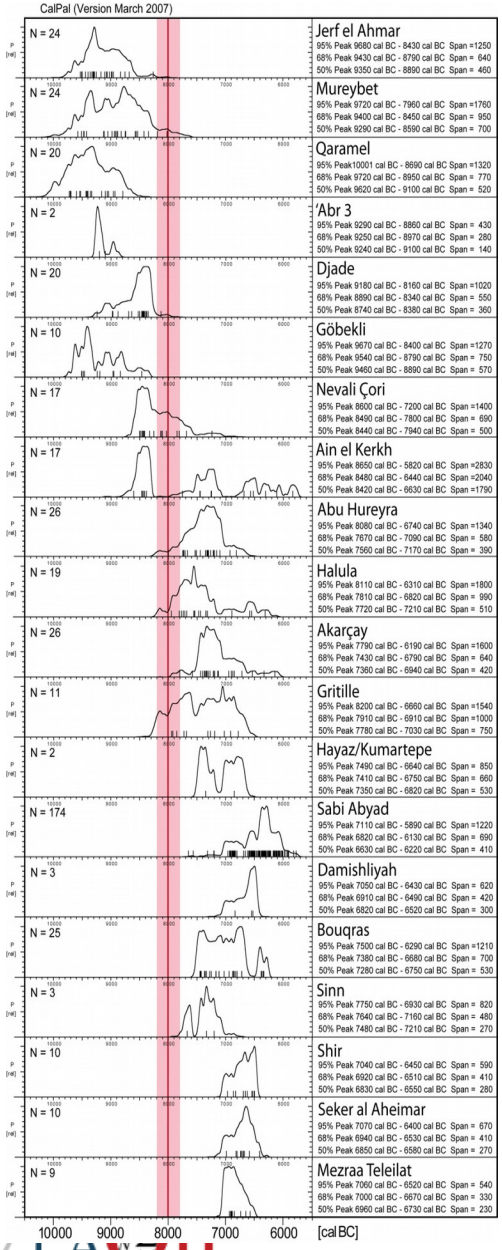
) DOI: 10.1007/s10816-013-9195-2

NEOLITICO INICIAL. Próximo oriente

Borrell, F., Junno, A., & Barceló, J. A. (2015). Synchronous Environmental and Cultural Change in the Emergence of Agricultural Economies 10,000 Years Ago in the Levant. *PloS one*, *10*(8), e0134810.

NEOLITICO INICIAL. Próximo oriente





452 radiocarbon dates, covering a span of ~ 3000 years, between 9700 and 6700 cal BC (From the PPNA to the Early Pottery Neolithic [PN]), shows a significant reduction in the volume of the archaeological signal around 8000 cal BC, indicating that the apparent uninterrupted sequence of settlements from PPNA to PN cannot be taken as unequivocal evidence of settlement continuity

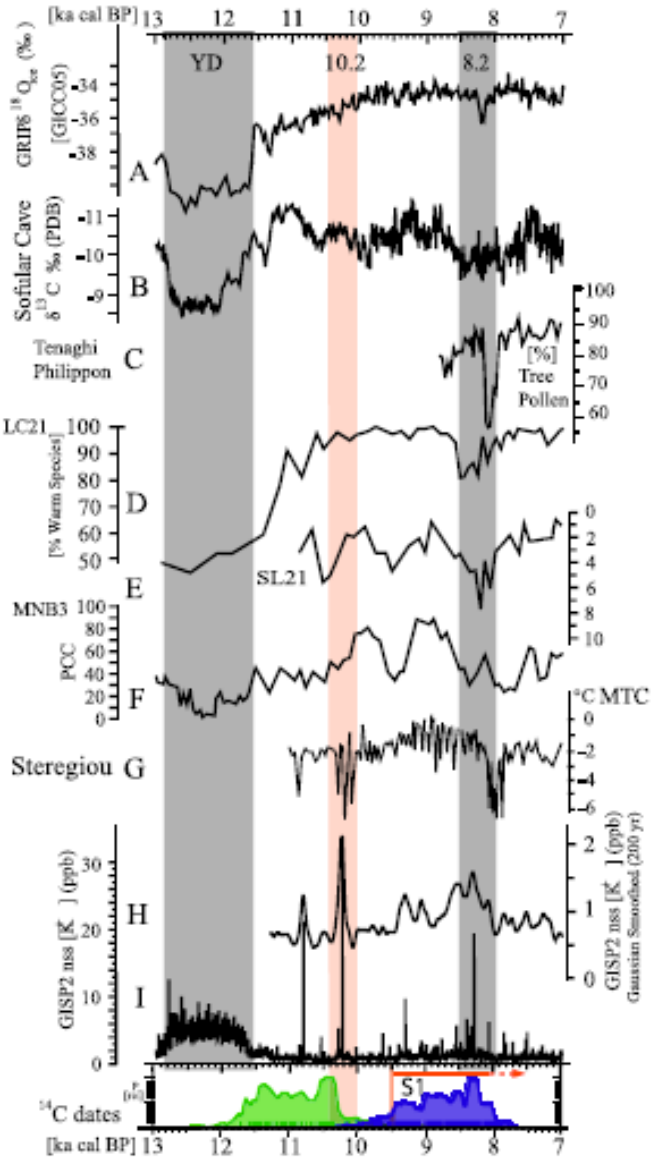


Fig 10. Palaeoclimate proxies from both the Eastern Mediterranean and the North Atlantic. Note the synchrony between 1) the 10.2 cal ky BP RCC and the marked decrease in the archaeological signal in the northern Levant, and 2) the boost observed in the archaeological signal and the beginning of the early Holocene sapropel S1 period (modified from ref. [70]).

What does it mean Spatio-Temporal ANALYSIS?

Distinction and separation of parts of spatio-temporal ordering of archaeological observables in order to know their relational structure,

Qualitative and quantitative examination of spatio-temporal relationships

Solving the where, when and why problems in archaeology.